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BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)
BACKGROUND DOCUMENT FOR
K061

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EXECUTIVE SUMMARY

BDAT Treatment Standards for K061

Pursuant to section 3004(m) of the Resource Conservation and Recovery Act as enacted by the Hazardous and Solid Waste Amendments on November 8, 1984, the Environmental Protection Agency (EPA) is establishing best demonstrated available technology (BDAT) treatment standards for the listed waste identified in 40 CFR 261.32 as K061. Compliance with these BDAT treatment standards is a prerequisite for placement of the waste in units designated as land disposal units according to 40 CFR Part 268.

This background document provides the Agency's rationale and technical support for selecting the constituents to be regulated in K061 waste and for developing treatment standards for those regulated constituents. The document also provides waste characterization and treatment information that serves as a basis for determining whether variances may be warranted. EPA may grant a treatment variance in cases where the Agency determines that the waste in question is more difficult to treat than the wastes upon which the BDAT treatment standards are based.

The introductory section, which appears verbatim in all the First Third background documents, summarizes the Agency's legal authority and promulgated methodology for establishing treatment standards and discusses the petition process necessary for requesting a variance from the treatment standards. The remainder of the document presents waste-specific information--the number and locations of facilities affected by the land disposal restrictions for K061 waste, the waste generating process, characterization data, the technologies used to treat the waste (or similar wastes), and available performance data, including data on which the treatment standards are based. The document also explains EPA's determination of BDAT, selection of constituents to be regulated, and calculation of treatment standards.

Waste code K061 is listed as "emission control dust/sludge from the primary production of steel in electric furnaces." The Standard Industrial Classification (SIC) code most often reported for the industry generating this waste code is 3312 (iron and steel production), and the Agency estimates that approximately 85 facilities have the potential to generate wastes identified as K061. EPA has determined that it is appropriate to divide K061 wastes into two treatability subcategories: a high zinc subcategory (greater than or equal to 15 percent zinc) and a low zinc subcategory (less than 15 percent zinc). Available information shows that the demonstrated technologies and associated treatability levels are different for each of these subcategories.

Treatment standards are being established for nonwastewater in both K061 subcategories. For wastewater in both K061 subcategories, EPA has not developed treatment standards as part of today's rule; EPA intends to develop treatment standards for wastewater in both of these subcategories by May 8, 1990. (For the purpose of determining the applicability of the treatment standards, wastewaters are defined as wastes containing less than 1 percent (weight basis) total suspended solids* and less than 1 percent (weight basis) total organic carbon (TOC). Waste not meeting this definition must comply with the treatment standards for nonwastewaters.)

For nonwastewater in the K061 high zinc subcategory, EPA is promulgating a standard of "no land disposal." This standard is based on treatment using high temperature metals recovery (HTMR) and reflects the fact that EPA expects to finalize a rule that will result in treated residuals from HTMR as not being classified as "K061 derived-from" wastes. (A more detailed discussion of the treatment standard for the K061 high zinc subcategory can be found in Section 7.) The effective date for the K061 high zinc subcategory treatment standard of "no land disposal" is August 8, 1990. EPA is also establishing interim final standards for the K061 high zinc subcategory based on stabilization. These standards do not represent BDAT; rather, they reflect the most practical treatment that can be accomplished immediately. The standards for high zinc wastes based on stabilization become effective on August 8, 1988, and lapse on August 7, 1990.

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*The term "total suspended solids" (TSS) clarifies EPA's previously used terminology of "total solids" and "filterable solids." Specifically, total suspended solids is measured by method 209C (Total Suspended Solids Dried at 103 to 105°C) in Standard Methods for the Examination of Water of Water and Wastewater, Sixteenth Edition.

For nonwastewater in the low zinc subcategory, EPA is promulgating treatment standards for cadmium, chromium, lead, and nickel. These standards are based on stabilization.

The following table presents the treatment standards for both subcategories of K061 nonwastewater. The interim treatment standards for the high zinc subcategory and the final standards for the low zinc subcategory reflect the concentration of constituents in the leachate from the Toxicity Characteristic Leaching Procedure (TCLP). The units for the leachate concentration are mg/l (parts per million on a weight-by-volume basis). If the concentrations of the regulated constituents in K061 waste, as generated, are lower than or equal to the proposed BDAT treatment standards, then treatment is not necessary as a prerequisite to land disposal.

Testing procedures are specifically identified in Appendix B of this background document.

BDAT Treatment Standards for K061

Constituent	Maximum for any single grab sample			
	Nonwastewater			Wastewater[a]
	Total concentration (mg/kg)	TCLP leachate concentration (mg/l)		Total concentration (mg/l)
		Interim[b]	Final[c]	
High zinc subcategory (zinc content equal to or greater than 15%)				
Cadmium	NA	0.14		
Chromium	NA	5.2	No Land Disposal Based on Recycling	
Lead	NA	0.24		
Nickel	NA	0.32		
Low zinc subcategory (zinc content less than 15%)				
Cadmium	NA	NA	0.14	
Chromium	NA	NA	5.2	
Lead	NA	NA	0.24	
Nickel	NA	NA	0.32	

NA = Not applicable.

[a] EPA intends to propose and promulgate wastewater treatment standards for K061 waste prior to May 8, 1990.

[b] Interim nonwastewater standards for high zinc subcategory waste are effective until August 8, 1990.

[c] Final nonwastewater standards for the low zinc subcategory are effective as of August 8, 1988. Final nonwastewater standards for the high zinc subcategory ("No Land Disposal Based on Recycling") go into effect on August 8, 1990.

1. INTRODUCTION

This section of the background document presents a summary of the legal authority pursuant to which the best demonstrated available technology (BDAT) treatment standards were developed, a summary of EPA's promulgated methodology for developing the BDAT treatment standards, and, finally, a discussion of the petition process that should be followed to request a variance from the BDAT treatment standards.

1.1 Legal Background

1.1.1 Requirements Under HSWA

The Hazardous and Solid Waste Amendments of 1984 (HSWA), which were enacted on November 8, 1984, and which amended the Resource Conservation and Recovery Act of 1976 (RCRA), impose substantial new responsibilities on those who handle hazardous waste. In particular, the amendments require the Agency to promulgate regulations that restrict the land disposal of untreated hazardous wastes. In its enactment of HSWA, Congress stated explicitly that "reliance on land disposal should be minimized or eliminated, and land disposal, particularly landfill and surface impoundment, should be the least favored method for managing hazardous wastes" (RCRA section 1002(b)(7), 42 U.S.C. 6901(b)(7)).

One part of the amendments specifies dates on which particular groups of untreated hazardous wastes will be prohibited from land disposal unless "it has been demonstrated to the Administrator, to a reasonable degree of certainty, that there will be no migration of hazardous constituents from the disposal unit or injection zone for as long as the wastes remain hazardous" (RCRA section 3004(d)(1), (e)(1), (g)(5), 42 U.S.C. 6924 (d)(1), (e)(1), (g)(5)).

For the purpose of the restrictions, HSWA defines land disposal "to include, but not be limited to, any placement of . . . hazardous waste in a landfill, surface impoundment, waste pile, injection well, land treatment facility, salt dome formation, salt bed formation, or underground mine or cave" (RCRA section 3004(k), 42 U.S.C. 6924(k)). Although HSWA defines land disposal to include injection wells, such disposal of solvents, dioxins, and certain other wastes, known as the California List wastes, is covered on a separate schedule (RCRA section 3004(f)(2), 42 U.S.C. 6924 (f)(2)). This schedule requires that EPA develop land disposal restrictions for deep well injection by August 8, 1988.

The amendments also require the Agency to set "levels or methods of treatment, if any, which substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste so that short-term and long-term threats to human health and the environment are minimized" (RCRA section 3004(m)(1), 42 U.S.C. 6924 (m)(1)). Wastes that satisfy such levels or methods of treatment established by EPA, i.e., treatment standards, are not prohibited from being land disposed.

In setting treatment standards for listed or characteristic wastes, EPA may establish different standards for particular wastes within a single waste code with differing treatability characteristics. One such characteristic is the physical form of the waste. This frequently leads to different standards for wastewaters and nonwastewaters. Alternatively, EPA can establish a treatment standard that is applicable to more than one waste code when, in EPA's judgment, a particular constituent present in the wastes can be treated to the same concentration in all the wastes.

In those instances where a generator can demonstrate that the standard promulgated for the generator's waste cannot be achieved, the amendments allow the Agency to grant a variance from a treatment standard by revising the treatment standard for that particular waste through rulemaking procedures. (A further discussion of treatment variances is provided in Section 1.3.)

The land disposal restrictions are effective when promulgated unless the Administrator grants a national variance and establishes a different date (not to exceed 2 years beyond the statutory deadline) based on "the earliest date on which adequate alternative treatment, recovery, or disposal capacity which protects human health and the environment will be available" (RCRA section 3004(h)(2), 42 U.S.C. 6924 (h)(2)).

If EPA fails to set treatment standards by the statutory deadline for any hazardous waste in the First Third or Second Third waste groups (see Section 1.1.2), the waste may not be disposed in a landfill or surface impoundment unless the facility is in compliance with the minimum technological requirements specified in section 3004(o) of RCRA. In addition, prior to disposal, the generator must certify to the Administrator that the availability of treatment capacity has been investigated, and it has been determined that disposal in a landfill or surface impoundment is the only practical alternative to treatment currently available to the generator. This restriction on the use of landfills and surface impoundments applies until EPA sets treatment standards for the waste or until May 8, 1990, whichever is sooner. If the Agency fails to set treatment standards for any ranked hazardous waste by May 8, 1990, the waste is automatically prohibited from land disposal unless the waste is placed in a land disposal unit that is the subject of a successful "no migration" demonstration (RCRA section 3004(g), 42 U.S.C. 6924(g)). "No migration" demonstrations are based on case-specific petitions that show there will be no migration of hazardous constituents from the unit for as long as the waste remains hazardous.

1.1.2 Schedule for Developing Restrictions

Under section 3004(g) of RCRA, EPA was required to establish a schedule for developing treatment standards for all wastes that the Agency had listed as hazardous by November 8, 1984. Section 3004(g) required that this schedule consider the intrinsic hazards and volumes associated with each of these wastes. The statute required EPA to set treatment standards according to the following schedule:

1. Solvent and dioxin wastes by November 8, 1986;
2. The "California List" wastes by July 8, 1987;
3. At least one-third of all listed hazardous wastes by August 8, 1988 (First Third);

4. At least two-thirds of all listed hazardous wastes by June 8, 1989 (Second Third); and

5. All remaining listed hazardous wastes and all hazardous wastes identified as of November 8, 1984, by one or more of the characteristics defined in 40 CFR Part 261 by May 8, 1990 (Third Third).

The statute specifically identified the solvent wastes as those covered under waste codes F001, F002, F003, F004, and F005; it identified the dioxin-containing hazardous wastes as those covered under waste codes F020, F021, F022, and F023.

Wastes collectively known as the California List wastes, defined under section 3004(d) of HSWA, are liquid hazardous wastes containing metals, free cyanides, PCBs, corrosives (i.e., a pH less than or equal to 2.0), and any liquid or nonliquid hazardous waste containing halogenated organic compounds (HOCs) above 0.1 percent by weight. Rules for the California List were proposed on December 11, 1986, and final rules for PCBs, corrosives, and HOC-containing wastes were established August 12, 1987. In that rule, EPA elected not to establish treatment standards for metals. Therefore, the statutory limits became effective.

On May 28, 1986, EPA published a final rule (51 FR 19300) that delineated the specific waste codes that would be addressed by the First Third, Second Third, and Third Third land disposal restriction rules. This schedule is incorporated into 40 CFR 268.10, 268.11, and 268.12.

1.2 Summary of Promulgated BDAT Methodology

In a November 7, 1986, rulemaking, EPA promulgated a technology-based approach to establishing treatment standards under section 3004(m).

Congress indicated in the legislative history accompanying the HSWA that "[t]he requisite levels of [sic] methods of treatment established by the Agency should be the best that has been demonstrated to be achievable," noting that the intent is "to require utilization of available technology" and not a "process which contemplates technology-forcing standards" (Vol. 130 Cong. Rec. S9178 (daily ed., July 25, 1984)). EPA has interpreted this legislative history as suggesting that Congress considered the requirement under section 3004(m) to be met by application of the best demonstrated and achievable (i.e., available) technology prior to land disposal of wastes or treatment residuals. Accordingly, EPA's treatment standards are generally based on the performance of the best demonstrated available technology (BDAT) identified for treatment of the hazardous constituents. This approach involves the identification of potential treatment systems, the determination of whether they are demonstrated and available, and the collection of treatment data from well-designed and well-operated systems.

The treatment standards, according to the statute, can represent levels or methods of treatment, if any, that substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents. Wherever possible, the Agency prefers to establish BDAT treatment standards as "levels" of treatment (i.e., performance standards), rather than to require the use of specific treatment "methods." EPA believes that concentration-based treatment levels offer the regulated community greater flexibility to develop and implement compliance strategies, as well as an incentive to develop innovative technologies.

1.2.1 Waste Treatability Group

In developing the treatment standards, EPA first characterizes the waste(s). As necessary, EPA may establish treatability groups for wastes having similar physical and chemical properties. That is, if EPA believes that hazardous constituents in wastes represented by different waste codes could be treated to similar concentrations using identical technologies, the Agency combines the wastes into one treatability group. EPA generally considers wastes to be similar when they are both generated from the same industry and from similar processing stages. In addition, EPA may combine two or more separate wastes into the same treatability group when data are available showing that the waste characteristics affecting performance are similar or that one of the wastes in the group, the waste from which treatment standards are to be developed, is expected to be most difficult to treat.

Once the treatability groups have been established, EPA collects and analyzes data on identified technologies used to treat the wastes in each treatability group. The technologies evaluated must be demonstrated on the waste or a similar waste and must be available for use.

1.2.2 Demonstrated and Available Treatment Technologies

Consistent with legislative history, EPA considers demonstrated technologies to be those that are currently used on a full-scale basis to treat the waste of interest or a waste judged to be similar (see 51 FR 40588, November 7, 1986). EPA also will consider as demonstrated treatment those technologies used to separate or otherwise process chemicals and other materials on a full-scale basis. Some of these technologies clearly are applicable to waste treatment, since the wastes are similar to raw materials processed in industrial applications.

For most of the waste treatability groups for which EPA will promulgate treatment standards, EPA will identify demonstrated technologies either through review of literature related to current waste treatment practices or on the basis of information provided by specific facilities currently treating the waste or similar wastes.

In cases where the Agency does not identify any facilities treating wastes represented by a particular waste treatability group, EPA may transfer a finding of demonstrated treatment. To do this, EPA will compare the parameters affecting treatment selection for the waste treatability group of interest to other wastes for which demonstrated technologies already have been determined. (The parameters affecting treatment selection and their use for this waste are described in Section 3.2 of this document.) If the parameters affecting treatment selection are similar, then the Agency will consider the treatment technology also to be demonstrated for the waste of interest. For example, EPA considers rotary kiln incineration to be a demonstrated technology for many waste codes containing hazardous organic constituents, high total organic content, and high filterable solids content, regardless of whether any facility is currently treating these wastes. The basis for this determination is data found in literature and data generated by EPA confirming the use of rotary kiln incineration on wastes having the above characteristics.

If no full-scale treatment or recovery operations are identified for a waste or wastes with similar physical or chemical characteristics that affect treatment selection, the Agency will be unable to identify any demonstrated treatment technologies for the waste, and, accordingly, the waste will be prohibited from land disposal (unless handled in accordance with the exemption and variance provisions of the rule). The Agency is, however, committed to establishing treatment standards as soon as new or improved treatment processes are demonstrated (and available).

Operations only available at research facilities, pilot- and bench-scale operations, will not be considered in identifying demonstrated treatment technologies for a waste. Nevertheless, EPA may use data generated at research facilities in assessing the performance of demonstrated technologies.

As discussed earlier, Congress intended that technologies used to establish treatment standards under section 3004(m) be not only "demonstrated," but also "available." To decide whether demonstrated technologies may be considered "available," the Agency determines whether they (1) are commercially available and (2) substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste. These criteria are discussed below.

1. Commercially available treatment. If the demonstrated treatment technology is a proprietary or patented process that is not generally available, EPA will not consider the technology in its determination of the treatment standards. EPA will consider proprietary or patented processes available if it determines that the treatment method can be purchased or licensed from the proprietor or is a commercially available treatment. The services of the commercial facility offering this technology often can be purchased even if the technology itself cannot be purchased.

2. Substantial treatment. To be considered "available," a demonstrated treatment technology must "substantially diminish the toxicity" of the waste or "substantially reduce the likelihood of migration of hazardous constituents" from the waste in accordance with section 3004(m). By requiring that substantial treatment be achieved in order to set a treatment standard, the statute ensures that all wastes are adequately treated before being placed in or on the land and ensures that the Agency does not require a treatment method that provides little or no environmental benefit. Treatment will always be deemed substantial if it results in nondetectable levels of the hazardous constituents of concern (provided the nondetectable levels are low relative to the concentrations in the untreated waste). If nondetectable levels are not achieved, then a determination of substantial treatment will be made on a case-by-case basis. This approach is necessary because of the difficulty of establishing a meaningful guideline that can be applied broadly to the many wastes and technologies to be considered. EPA will consider the following factors in an effort to evaluate whether a technology provides substantial treatment on a case-by-case basis:

   - Number and types of constituents treated;
   - Performance (concentration of the constituents in the treatment residuals); and
   - Percent of constituents removed.

EPA will only set treatment standards based on a technology that meets both availability criteria. Thus, the decision to classify a technology as "unavailable" will have a direct impact on the treatment standard. If the best demonstrated technology is unavailable, the treatment standards will be based on the next best demonstrated treatment technology determined to be available. To the extent that the resulting treatment standards are less stringent, greater concentrations of hazardous constituents in the treatment residuals could be placed in land disposal units.

There also may be circumstances in which EPA concludes that for a given waste none of the demonstrated treatment technologies are "available" for purposes of establishing the 3004(m) treatment performance standards. Subsequently, these wastes will be prohibited from continued placement in or on the land unless managed in accordance with applicable exemptions and variance provisions. The Agency is, however, committed to establishing new treatment standards as soon as new or improved treatment processes become available.

1.2.3 Collection of Performance Data

Performance data on the demonstrated available technologies are evaluated by the Agency to determine whether the data are representative of well-designed and well-operated treatment systems. Only data from well-designed and well-operated systems are considered in determining BDAT. The data evaluation includes data already collected directly by

EPA and/or data provided by industry. In those instances where additional data are needed to supplement existing information, EPA collects additional data through a sampling and analysis program. The principal elements of this data collection program are: (1) the identification of facilities for site visits, (2) the engineering site visit, (3) the sampling and analysis plan, (4) the sampling visit, and (5) the onsite engineering report.

(1) Identification of facilities for site visits. To identify facilities that generate and/or treat the waste of concern, EPA uses a number of information sources. These include Stanford Research Institute's Directory of Chemical Producers; EPA's Hazardous Waste Data Management System (HWDMS); the 1986 Treatment, Storage, Disposal Facility (TSDF) National Screening Survey; and EPA's Industry Studies Data Base. In addition, EPA contacts trade associations to inform them that the Agency is considering visits to facilities in their industry and to solicit their assistance in identifying facilities for EPA to consider in its treatment sampling program.

After identifying facilities that treat the waste, EPA uses this hierarchy to select sites for engineering visits: (1) generators treating single wastes on site; (2) generators treating multiple wastes togetner on site; (3) commercial treatment, storage, and disposal facilities (TSDFs); and (4) EPA in-house treatment. This hierarchy is based on two concepts: (1) to the extent possible, EPA should develop treatment standards from data produced by treatment facilities handling only a single waste, and (2) facilities that routinely treat a specific waste have had the best opportunity to optimize design parameters. Although excellent treatment can occur at many facilities that are not high in this hierarchy, EPA has adopted this approach to avoid, when possible, ambiguities related to the mixing of wastes before and during treatment.

When possible, the Agency will evaluate treatment technologies using full-scale treatment systems. If performance data from properly designed and operated full-scale systems treating a particular waste or a waste judged to be similar are not available, EPA may use data from research facility operations. Whenever research facility data are used, EPA will explain in the preamble and background document why such data were used and will request comments on the use of such data.

Although EPA's data bases provide information on treatment for individual wastes, the data bases rarely provide data that support the selection of one facility for sampling over another. In cases where several treatment sites appear to fall into the same level of the hierarchy, EPA selects sites for visits strictly on the basis of which facility could most expeditiously be visited and later sampled if justified by the engineering visit.

(2) Engineering site visit. Once a treatment facility has been selected, an engineering site visit is made to confirm that a candidate for sampling meets EPA's criteria for a well-designed facility and to

ensure that the necessary sampling points can be accessed to determine operating parameters and treatment effectiveness. During the visit, EPA also confirms that the facility appears to be well operated, although the actual operation of the treatment system during sampling is the basis for EPA's decisions regarding proper operation of the treatment unit. In general, the Agency considers a well-designed facility to be one that contains the unit operations necessary to treat the various hazardous constituents of the waste, as well as to control other nonhazardous materials in the waste that may affect treatment performance.

In addition to ensuring that a system is reasonably well designed, the engineering visit examines whether the facility has a way to measure the operating parameters that affect performance of the treatment system during the waste treatment period. For example, EPA may choose not to sample a treatment system that operates in a continuous mode, for which an important operating parameter cannot be continuously recorded. In such systems, instrumentation is important in determining whether the treatment system is operating at design values during the waste treatment period.

(3) Sampling and analysis plan. If after the engineering site visit the Agency decides to sample a particular plant, the Agency will then develop a site-specific sampling and analysis plan (SAP) according to the Generic Quality Assurance Project Plan for the Land Disposal Restrictions Program ("BDAT"), EPA/530-SW-87-011. In brief, the SAP discusses where the Agency plans to sample, how the samples will be taken, the frequency

of sampling, the constituents to be analyzed and the method of analysis, operational parameters to be obtained, and specific laboratory quality control checks on the analytical results.

The Agency will generally produce a draft of the site-specific SAP within 2 to 3 weeks of the engineering visit. The draft of the SAP is then sent to the plant for review and comment. With few exceptions, the draft SAP should be a confirmation of data collection activities discussed with the plant personnel during the engineering site visit. EPA encourages plant personnel to recommend any modifications to the SAP that they believe will improve the quality of the data.

It is important to note that sampling of a plant by EPA does not mean that the data will be used in the development of BDAT treatment standards. EPA's final decision on whether to use data from a sampled plant depends on the actual analysis of the waste being treated and on the operating conditions at the time of sampling. Although EPA would not plan to sample a facility that was not ostensibly well designed and well operated, there is no way to ensure that at the time of the sampling the facility will not experience operating problems. Additionally, EPA statistically compares its test data to suitable industry-provided data, where available, in its determination of what data to use in developing treatment standards. The methodology for comparing data is presented later in this section.

(Note: Facilities wishing to submit data for consideration in the development of BDAT standards should, to the extent possible, provide sampling information similar to that acquired by EPA. Such facilities should review the Generic Quality Assurance Project Plan for the Land Disposal Restrictions Program ("BDAT"), which delineates all of the quality control and quality assurance measures associated with sampling and analysis. Quality assurance and quality control procedures are summarized in Section 1.2.6 of this document.)

(4) Sampling visit. The purpose of the sampling visit is to collect samples that characterize the performance of the treatment system and to document the operating conditions that existed during the waste treatment period. At a minimum, the Agency attempts to collect sufficient samples of the untreated waste and solid and liquid treatment residuals so that variability in the treatment process can be accounted for in the development of the treatment standards. To the extent practicable, and within safety constraints, EPA or its contractors collect all samples and ensure that chain-of-custody procedures are conducted so that the integrity of the data is maintained.

In general, the samples collected during the sampling visit will have already been specified in the SAP. In some instances, however, EPA will not be able to collect all planned samples because of changes in the facility operation or plant upsets; EPA will explain any such deviations from the SAP in its follow-up onsite engineering report.

(5) Onsite engineering report. EPA summarizes all its data collection activities and associated analytical results for testing at a facility in a report referred to as the onsite engineering report (OER). This report characterizes the waste(s) treated, the treated residual concentrations, the design and operating data, and all analytical results including methods used and accuracy results. This report also describes any deviations from EPA's suggested analytical methods for hazardous wastes that appear in Test Methods for Evaluating Solid Waste, SW-846, Third Edition, November 1986.

After the OER is completed, the report is submitted to the waste generator and/or treater for review. This review provides a final opportunity for claiming any information contained in the report as confidential. Following the review and incorporation of comments, as appropriate, the report is made available to the public with the exception of any material claimed as confidential.

1.2.4 Hazardous Constituents Considered and Selected for Regulation

(1) Development of BDAT list. The list of hazardous constituents within the waste codes that are targeted for treatment is referred to by the Agency as the BDAT constituent list. This list, provided as Table 1-1, is derived from the constituents presented in 40 CFR Part 261, Appendices VII and VIII, as well as several ignitable constituents used as the basis of listing wastes as F003 and F005. These sources provide a

Table 1-1 BDAT Constituent List

BDAT reference no.	Constituent	CAS no.
	Volatile organics	
222.	Acetone	67-64-1
1.	Acetonitrile	75-05-8
2.	Acrolein	107-02-8
3.	Acrylonitrile	107-13-1
4.	Benzene	71-43-2
5.	Bromodichloromethane	75-27-4
6.	Bromomethane	74-83-9
223.	n-Butyl alcohol	71-36-3
7.	Carbon tetrachloride	56-23-5
8.	Carbon disulfide	75-15-0
9.	Chlorobenzene	108-90-7
10.	2-Chloro-1,3-butadiene	126-99-8
11.	Chlorodibromomethane	124-48-1
12.	Chloroethane	75-00-3
13.	2-Chloroethyl vinyl ether	110-75-8
14.	Chloroform	67-66-3
15.	Chloromethane	74-87-3
16.	3-Chloropropene	107-05-1
17.	1,2-Dibromo-3-chloropropane	96-12-8
18.	1,2-Dibromoethane	106-93-4
19.	Dibromomethane	74-95-3
20.	trans-1,4-Dichloro-2-butene	110-57-6
21.	Dichlorodifluoromethane	75-71-8
22.	1,1-Dichloroethane	75-34-3
23.	1,2-Dichloroethane	107-06-2
24.	1,1-Dichloroethylene	75-35-4
25.	trans-1,2-Dichloroethene	156-60-5
26.	1,2-Dichloropropane	78-87-5
27.	trans-1,3-Dichloropropene	10061-02-6
28.	cis-1,3-Dichloropropene	10061-01-5
29.	1,4-Dioxane	123-91-1
224.	2-Ethoxyethanol	110-80-5
225.	Ethyl acetate	141-78-6
226.	Ethyl benzene	100-41-4
30.	Ethyl cyanide	107-12-0
227.	Ethyl ether	60-29-7
31.	Ethyl methacrylate	97-63-2
214.	Ethylene oxide	75-21-8
32.	Iodomethane	74-88-4
33.	Isobutyl alcohol	78-83-1
228.	Methanol	67-56-1
34.	Methyl ethyl ketone	78-93-3

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Volatile organics (continued)	
229.	Methyl isobutyl ketone	108-10-1
35.	Methyl methacrylate	80-62-6
37.	Methacrylonitrile	126-98-7
38.	Methylene chloride	75-09-2
230.	2-Nitropropane	79-46-9
39.	Pyridine	110-86-1
40.	1,1,1,2-Tetrachloroethane	630-20-6
41.	1,1,2,2-Tetrachloroethane	79-34-6
42.	Tetrachloroethene	127-18-4
43.	Toluene	108-88-3
44.	Tribromomethane	75-25-2
45.	1,1,1-Trichloroethane	71-55-6
46.	1,1,2-Trichloroethane	79-00-5
47.	Trichloroethene	79-01-6
48.	Trichloromonofluoromethane	75-69-4
49.	1,2,3-Trichloropropane	96-18-4
231.	1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1
50.	Vinyl chloride	75-01-4
215.	1,2-Xylene	97-47-6
216.	1,3-Xylene	108-38-3
217.	1,4-Xylene	106-44-5
	Semivolatile organics	
51.	Acenaphthalene	208-96-8
52.	Acenaphthene	83-32-9
53.	Acetophenone	96-86-2
54.	2-Acetylaminofluorene	53-96-3
55.	4-Aminobiphenyl	92-67-1
56.	Aniline	62-53-3
57.	Anthracene	120-12-7
58.	Aramite	140-57-8
59.	Benz(a)anthracene	56-55-3
218.	Benzal chloride	98-87-3
60.	Benzenethiol	108-98-5
61.	Deleted	
62.	Benzo(a)pyrene	50-32-8
63.	Benzo(b)fluoranthene	205-99-2
64.	Benzo(ghi)perylene	191-24-2
65.	Benzo(k)fluoranthene	207-08-9
66.	p-Benzoquinone	106-51-4

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Semivolatile organics (continued)	
67.	Bis(2-chloroethoxy)methane	111-91-1
68.	Bis(2-chloroethyl)ether	111-44-4
69.	Bis(2-chloroisopropyl)ether	39638-32-9
70.	Bis(2-ethylhexyl)phthalate	117-81-7
71.	4-Bromophenyl phenyl ether	101-55-3
72.	Butyl benzyl phthalate	85-68-7
73.	2-sec-Butyl-4,6-dinitrophenol	88-85-7
74.	p-Chloroaniline	106-47-8
75.	Chlorobenzilate	510-15-6
76.	p-Chloro-m-cresol	59-50-7
77.	2-Chloronaphthalene	91-58-7
78.	2-Chlorophenol	95-57-8
79.	3-Chloropropionitrile	542-76-7
80.	Chrysene	218-01-9
81.	ortho-Cresol	95-48-7
82.	para-Cresol	106-44-5
232.	Cyclohexanone	108-94-1
83.	Dibenz(a,h)anthracene	53-70-3
84.	Dibenzo(a,e)pyrene	192-65-4
85.	Dibenzo(a,i)pyrene	189-55-9
86.	m-Dichlorobenzene	541-73-1
87.	o-Dichlorobenzene	95-50-1
88.	p-Dichlorobenzene	106-46-7
89.	3,3'-Dichlorobenzidine	91-94-1
90.	2,4-Dichlorophenol	120-83-2
91.	2,6-Dichlorophenol	87-65-0
92.	Diethyl phthalate	84-66-2
93.	3,3'-Dimethoxybenzidine	119-90-4
94.	p-Dimethylaminoazobenzene	60-11-7
95.	3,3'-Dimethylbenzidine	119-93-7
96.	2,4-Dimethylphenol	105-67-9
97.	Dimethyl phthalate	131-11-3
98.	Di-n-butyl phthalate	84-74-2
99.	1,4-Dinitrobenzene	100-25-4
100.	4,6-Dinitro-o-cresol	534-52-1
101.	2,4-Dinitrophenol	51-28-5
102.	2,4-Dinitrotoluene	121-14-2
103.	2,6-Dinitrotoluene	606-20-2
104.	Di-n-octyl phthalate	117-84-0
105.	Di-n-propylnitrosamine	621-64-7
106.	Diphenylamine	122-39-4
219.	Diphenylnitrosamine	86-30-6

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Semivolatile organics (continued)	
107.	1,2-Diphenylhydrazine	122-66-7
108.	Fluoranthene	206-44-0
109.	Fluorene	86-73-7
110.	Hexachlorobenzene	118-74-1
111.	Hexachlorobutadiene	87-68-3
112.	Hexachlorocyclopentadiene	77-47-4
113.	Hexachloroethane	67-72-1
114.	Hexachlorophene	70-30-4
115.	Hexachloropropene	1888-71-7
116.	Indeno(1,2,3-cd)pyrene	193-39-5
117.	Isosafrole	120-58-1
118.	Methapyrilene	91-80-5
119.	3-Methylcholanthrene	56-49-5
120.	4,4'-Methylenebis (2-chloroaniline)	101-14-4
36.	Methyl methanesulfonate	66-27-3
121.	Naphthalene	91-20-3
122.	1,4-Naphthoquinone	130-15-4
123.	1-Naphthylamine	134-32-7
124.	2-Naphthylamine	91-59-8
125.	p-Nitroaniline	100-01 6
126.	Nitrobenzene	98-95-3
127.	4-Nitrophenol	100-02-7
128.	N-Nitrosodi-n-butylamine	924-16-3
129.	N-Nitrosodiethylamine	55-18-5
130.	N-Nitrosodimethylamine	62-75-9
131.	N-Nitrosomethylethylamine	10595-95-6
132.	N-Nitrosomorpholine	59-89-2
133.	N-Nitrosopiperidine	100-75-4
134.	N-Nitrosopyrrolidine	930-55-2
135.	5-Nitro-o-toluidine	99-65-8
136.	Pentachlorobenzene	608-93-5
137.	Pentachloroethane	76-01-7
138.	Pentachloronitrobenzene	82-68-8
139.	Pentachlorophenol	87-86-5
140.	Phenacetin	62-44-2
141.	Phenanthrene	85-01-8
142.	Phenol	108-95-2
220.	Phthalic anhydride	85-44-9
143.	2-Picoline	109-06-8
144.	Pronamide	23950-58-5
145.	Pyrene	129-00-0
146.	Resorcinol	108-46-3

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Semivolatile organics (continued)	
147.	Safrole	94-59-7
148.	1,2,4,5-Tetrachlorobenzene	95-94-3
149.	2,3,4,6-Tetrachlorophenol	58-90-2
150.	1,2,4-Trichlorobenzene	120-82-1
151.	2,4,5-Trichlorophenol	95-95-4
152.	2,4,6-Trichlorophenol	88-06-2
153.	Tris(2,3-dibromopropyl) phosphate	126-72-7
	Metals	
154.	Antimony	7440-36-0
155.	Arsenic	7440-38-2
156.	Barium	7440-39-3
157.	Beryllium	7440-41-7
158.	Cadmium	7440-43-9
159.	Chromium (total)	7440-47-3
221.	Chromium (hexavalent)	-
160.	Copper	7440-50-8
161.	Lead	7439-92-1
162.	Mercury	7439-97-6
163.	Nickel	7440-02-0
164.	Selenium	7782-49-2
165.	Silver	7440-22-4
166.	Thallium	7440-28-0
167.	Vanadium	7440-62-2
168.	Zinc	7440-66-6
	Inorganics other than metals	
169.	Cyanide	57-12-5
170.	Fluoride	16964-48-8
171.	Sulfide	8496-25-8
	Organochlorine pesticides	
172.	Aldrin	309-00-2
173.	alpha-BHC	319-84-6
174.	beta-BHC	319-85-7
175.	delta-BHC	319-86-8

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Organochlorine pesticides (continued)	
176.	gamma-BHC	58-89-9
177.	Chlordane	57-74-9
178.	DDD	72-54-8
179.	DDE	72-55-9
180.	DDT	50-29-3
181.	Dieldrin	60-57-1
182.	Endosulfan I	939-98-8
183.	Endosulfan II	33213-6-5
184.	Endrin	72-20-8
185.	Endrin aldehyde	7421-93-4
186.	Heptachlor	76-44-8
187.	Heptachlor epoxide	1024-57-3
188.	Isodrin	465-73-6
189.	Kepone	143-50-0
190.	Methoxyclor	72-43-5
191.	Toxaphene	8001-35-2
	Phenoxyacetic acid herbicides	
192.	2,4-Dichlorophenoxyacetic acid	94-75-7
193.	Silvex	93-72-1
194.	2,4,5-T	93-76-5
	Organophosphorous insecticides	
195.	Disulfoton	298-04-4
196.	Famphur	52-85-7
197.	Methyl parathion	298-00-0
198.	Parathion	56-38-2
199.	Phorate	298-02-2
	PCBs	
200.	Aroclor 1016	12674-11-2
201.	Aroclor 1221	11104-28-2
202.	Aroclor 1232	11141-16-5
203.	Aroclor 1242	53469-21-9
204.	Aroclor 1248	12672-29-6
205.	Aroclor 1254	11097-69-1
206.	Aroclor 1260	11096-82-5

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Dioxins and furans	
207.	Hexachlorodibenzo-p-dioxins	-
208.	Hexachlorodibenzofurans	-
209.	Pentachlorodibenzo-p-dioxins	-
210.	Pentachlorodibenzofurans	-
211.	Tetrachlorodibenzo-p-dioxins	-
212.	Tetrachlorodibenzofurans	-
213.	2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6

comprehensive list of hazardous constituents specifically regulated under RCRA. The BDAT list consists of those constituents that can be analyzed using methods published in SW-846, Third Edition.

The initial BDAT constituent list was published in EPA's Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT") in March 1987. Additional constituents are added to the BDAT constituent list as more key constituents are identified for specific waste codes or as new analytical methods are developed for hazardous constituents. For example, since the list was published in March 1987, 18 additional constituents (hexavalent chromium, xylenes (all three isomers), benzal chloride, phthalic anhydride, ethylene oxide, acetone, n-butyl alcohol, 2-ethoxyethanol, ethyl acetate, ethyl benzene, ethyl ether, methanol, methyl isobutyl ketone, 2-nitropropane, 1,1,2-trichloro-1,2,2-trifluoroethane, and cyclohexanone) have been added to the list.

Chemicals are listed in Appendix VIII if they are shown in scientific studies to have toxic, carcinogenic, mutagenic, or teratogenic effects on humans or other life-forms, and they include such substances as those identified by the Agency's Carcinogen Assessment Group as being carcinogenic. A waste can be listed as a toxic waste on the basis that it contains a constituent in Appendix VIII.

Although Appendix VII, Appendix VIII, and the F003 and F005 ignitables provide a comprehensive list of RCRA-regulated hazardous constituents, not all of the constituents can be analyzed in a complex waste matrix. Therefore, constituents that could not be readily analyzed in an unknown waste matrix were not included on the initial BDAT constituent list. As mentioned above, however, the BDAT constituent list is a continuously growing list that does not preclude the addition of new constituents when analytical methods are developed.

There are five major reasons that constituents were not included on the BDAT constituent list:

1. Constituents are unstable. Based on their chemical structure, some constituents will either decompose in water or will ionize. For example, maleic anhydride will form maleic acid when it comes in contact with water, and copper cyanide will ionize to form copper and cyanide ions. However, EPA may choose to regulate the decomposition or ionization products.

2. EPA-approved or verified analytical methods are not available. Many constituents, such as 1,3,5-trinitrobenzene, are not measured adequately or even detected using any of EPA's analytical methods published in SW-846 Third Edition.

3. The constituent is a member of a chemical group designated in Appendix VIII as not otherwise specified (N.O.S.). Constituents listed as N.O.S., such as chlorinated phenols, are a generic group of some types of chemicals for which a single analytical procedure is not available. The individual members of each such group need to be listed to determine whether the constituents can be analyzed. For each N.O.S. group, all those constituents that can be readily analyzed are included in the BDAT constituent list.

4. Available analytical procedures are not appropriate for a complex waste matrix. Some compounds, such as auramine, can be analyzed as a pure constituent. However, in the presence of other constituents, the recommended analytical method does not positively identify the constituent. The use of high performance liquid chromatography (HPLC) presupposes a high expectation of finding the specific constituents of interest. In using this procedure to screen samples, protocols would have to be developed on a case-specific basis to verify the identity of constituents present in the samples. Therefore, HPLC is usually not an appropriate analytical procedure for complex samples containing unknown constituents.

5. Standards for analytical instrument calibration are not commercially available. For several constituents, such as benz(c)acridine, commercially available standards of a "reasonably" pure grade are not available. The unavailability of a standard was determined by a review of catalogs from specialty chemical manufacturers.

Two constituents (fluoride and sulfide) are not specifically included in Appendices VII and VIII; however, these compounds are included on the BDAT list as indicator constituents for compounds from Appendices VII and VIII such as hydrogen fluoride and hydrogen sulfide, which ionize in water.

The BDAT constituent list presented in Table 1-1 is divided into the following nine groups:

- Volatile organics;
- Semivolatile organics;
- Metals;
- Other inorganics;
- Organochlorine pesticides;
- Phenoxyacetic acid herbicides;
- Organophosphorous insecticides;
- PCBs; and
- Dioxins and furans.

The constituents were placed in these categories based on their chemical properties. The constituents in each group are expected to behave similarly during treatment and are also analyzed, with the exception of the metals and the other inorganics, by using the same analytical methods.

(2) Constituent selection analysis. The constituents that the Agency selects for regulation in each waste are, in general, those found in the untreated wastes at treatable concentrations. For certain waste

codes, the target list for the untreated waste may have been shortened (relative to analyses performed to test treatment technologies) because of the extreme unlikelihood that the constituent will be present.

In selecting constituents for regulation, the first step is to develop of list of potentially regulated constituents by summarizing all the constituents that are present or are likely to be present in the untreated waste at treatable concentrations. A constituent is considered present in a waste if the constituent (1) is detected in the untreated waste above the detection limit, (2) is detected in any of the treated residuals above the detection limit, or (3) is likely to be present based on the Agency's analyses of the waste-generating process. In case (2), the presence of other constituents in the untreated waste may interfere with the quantification of the constituent of concern, making the detection limit relatively high and resulting in a finding of "not detected" when, in fact, the constituent is present in the waste. Thus, the Agency reserves the right to regulate such constituents.

After developing a list of potential constituents for regulation. EPA reviews this list to determine if any of these constituents can be excluded from regulation because they would be controlled by regulation of other constituents on the list. This indicator analysis is done for two reasons: (1) it reduces the analytical cost burdens on the treater and (2) it facilitates implementation of the compliance and enforcement program. EPA's rationale for selection of regulated constituents for this waste code is presented in Section 6 of this background document.

(3) Calculation of standards. The final step in the calculation of the BDAT treatment standard is the multiplication of the average accuracy-corrected treatment value by a factor referred to by the Agency as the variability factor. This calculation takes into account that even well-designed and well-operated treatment systems will experience some fluctuations in performance. EPA expects that fluctuations will result from inherent mechanical limitations in treatment control systems, collection of treated samples, and analysis of these samples. All of the above fluctuations can be expected to occur at well-designed and well-operated treatment facilities. Therefore, setting treatment standards utilizing a variability factor should be viewed not as a relaxing of section 3004(m) requirements, but rather as a function of the normal variability of the treatment processes. A treatment facility will have to be designed to meet the mean achievable treatment performance level to ensure that the performance levels remain within the limits of the treatment standard.

The Agency calculates a variability factor for each constituent of concern within a waste treatability group using the statistical calculation presented in Appendix A. The equation for calculating the variability factor is the same as that used by EPA for the development of numerous regulations in the Effluent Guidelines Program under the Clean Water Act. The variability factor establishes the instantaneous maximum based on the 99th percentile value.

There is an additional step in the calculation of the treatment standards in those instances where the ANOVA analysis shows that more than one technology achieves a level of performance that represents BDAT. In such instances, the BDAT treatment standard for each constituent of concern is calculated by first averaging the mean performance value for each technology and then multiplying that value by the highest variability factor among the technologies considered. This procedure ensures that all the technologies used as the basis for the BDAT treatment standards will achieve full compliance.

1.2.5 Compliance with Performance Standards

Usually the treatment standards reflect performance achieved by the best demonstrated available technology (BDAT). As such, compliance with these numerical standards requires only that the treatment level be achieved prior to land disposal. It does not require the use of any particular treatment technology. While dilution of the waste as a means to comply with the standards is prohibited, wastes that are generated in such a way as to naturally meet the standards can be land disposed without treatment. With the exception of treatment standards that prohibit land disposal or that specify use of certain treatment methods, all established treatment standards are expressed as concentration levels.

EPA is using both the total constituent concentration and the concentration of the constituent in the TCLP extract of the treated waste as a measure of technology performance.

For all organic constituents, EPA is basing the treatment standards on the total constituent concentration found in the treated waste. EPA is using this measurement because most technologies for treatment of organics destroy or remove organics compounds. Accordingly, the best measure of performance would be the total amount of constituent remaining after treatment. (NOTE: EPA's land disposal restrictions for solvent waste codes F001-F005 (51 FR 40572) use the TCLP extract value as a measure of performance. At the time that EPA promulgated the treatment standards for F001-F005, useful data were not available on total constituent concentrations in treated residuals, and, as a result, the TCLP data were considered to be the best measure of performance.)

For all metal constituents, EPA is using both total constituent concentration and/or the TCLP extract concentration as the basis for treatment standards. The total constituent concentration is being used when the technology basis includes a metal recovery operation. The underlying principle of metal recovery is that it reduces the amount of metal in a waste by separating the metal for recovery; total constituent concentration in the treated residual, therefore, is an important measure of performance for this technology. Additionally, EPA also believes that it is important that any remaining metal in a treated residual waste not be in a state that is easily leachable; accordingly, EPA is also using the TCLP extract concentration as a measure of performance. It is important to note that for wastes for which treatment standards are based on a metal recovery process, the facility has to comply with both the total and the TCLP extract constituent concentrations prior to land disposing the waste.

In cases where treatment standards for metals are not based on recovery techniques but rather on stabilization, EPA is using only the TCLP value as a measure of performance. The Agency's rationale is that stabilization is not meant to reduce the concentration of metal in a waste but only to chemically minimize the ability of the metal to leach.

1.2.6 Identification of BDAT

BDAT for a waste must be the "best" of the demonstrated available technologies. EPA determines which technology constitutes "best" after screening the available data from each demonstrated technology, adjusting these data for accuracy, and comparing the performance of each demonstrated technology to that of the others. If only one technology is identified as demonstrated, it is considered "best"; if it is available, the technology is BDAT.

(1) Screening of treatment data. The first activity in determining which of the treatment technologies represent treatment by BDAT is to screen the treatment performance data from each of the demonstrated and available technologies according to the following criteria:

1. Design and operating data associated with the treatment data must reflect a well-designed, well-operated system for each treatment data point. (The specific design and operating parameters for each demonstrated technology for the waste code(s) of interest are discussed in Section 3.2 of this document.)

2. Sufficient QA/QC data must be available to determine the true values of the data from the treated waste. This screening criterion involves adjustment of treated data to take into account that the true value may be different from the measured value. This discrepancy generally is caused by other constituents in the waste that can mask results or otherwise interfere with the analysis of the constituent of concern.

3. The measure of performance must be consistent with EPA's approach to evaluating treatment by type of constituents (e.g., total concentration data for organics, and total concentration and TCLP extract concentration for metals from the residual).

In the absence of data needed to perform the screening analysis, EPA will make decisions on a case-by-case basis as to whether to use the data as a basis for the treatment standards. The factors included in this case-by-case analysis will be the actual treatment levels achieved, the availability of the treatment data and their completeness (with respect to the above criteria), and EPA's assessment of whether the untreated waste represents the waste code of concern.

(2) Comparison of treatment data. In cases in which EPA has treatment data from more than one demonstrated available technology following the screening activity, EPA uses the statistical method known as analysis of variance (ANOVA) to determine if one technology performs significantly better than the others. This statistical method (summarized in Appendix A) provides a measure of the differences between two data sets. Specifically, EPA uses the analysis of variance to determine whether BDAT represents a level of performance achieved by only one technology or represents a level of performance achieved by more than one (or all) of the technologies. If EPA finds that one technology performs significantly better (i.e., is "best"), BDAT treatment standards

are the level of performance achieved by that best technology multiplied by the corresponding variability factor for each regulated constituent. If the Agency finds that the levels of performance for one or more technologies are not statistically different, EPA averages the performance values achieved by each technology and then multiplies this value by the largest variability factor associated with any of the technologies.

(3) Quality assurance/quality control. This section presents the principal quality assurance/quality control (QA/QC) procedures employed in screening and adjusting the data to be used in the calculation of treatment standards. Additional QA/QC procedures used in collecting and screening data for the BDAT program are presented in EPA's Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT"), EPA/530-SW-87-011.

To calculate the treatment standards for the land disposal restriction rules, it is first necessary to determine the recovery value for each constituent (the amount of constituent recovered after spiking--which is the addition of a known amount of the constituent--minus the initial concentration in the samples, all divided by the spike amount added) for each spiked sample of the treated residual. Once the recovery values are determined, the following procedures are used to select the appropriate percent recovery value to adjust the analytical data:

1. If duplicate spike recovery values are available for the constituent of interest, the data are adjusted by the lowest available percent recovery value (i.e., the value that will yield the most conservative estimate of treatment achieved). However, if a spike recovery value of less than 20 percent is reported for a specific constituent, the data are not used to set treatment standards because the Agency does not have sufficient confidence in the reported value to set a national standard.

2. If data are not available for a specific constituent but are available for an isomer, then the spike recovery data are transferred from the isomer and the data are adjusted using the percent recovery selected according to the procedure described in (1) above.

3. If data are not available for a specific constituent but are available for a similar class of constituents (e.g., volatile organics, acid-extractable semivolatiles), then spike recovery data available for this class of constituents are transferred. All spike recovery values greater than or equal to 20 percent for a spike sample are averaged and the constituent concentration is adjusted by the average recovery value. If spiked recovery data are available for more than one sample, the average is calculated for each sample and the data are adjusted by using the lowest average value.

4. If matrix spike recovery data are not available for a set of data to be used to calculate treatment standards, then matrix spike recovery data are transferred from a waste that the Agency believes is similar (e.g., if the data represent an ash from incineration, then data from other incinerator ashes could be used). While EPA recognizes that transfer of matrix spike recovery data from a similar waste is not an exact analysis, this is considered the best approach for adjusting the data to account for the fact that most analyses do not result in extraction of 100 percent of the constituent. In assessing the recovery data to be transferred, the procedures outlined in (1), (2), and (3) above are followed.

The analytical procedures employed to generate the data used to calculate the treatment standards are listed in Appendix B of this document. In cases where alternatives or equivalent procedures and/or equipment are allowed in EPA's SW-846, Third Edition methods, the specific procedures and equipment used are documented. In addition, any deviations from the SW-846, Third Edition methods used to analyze the specific waste matrices are documented. It is important to note that the Agency will use the methods and procedures delineated in Appendix B to enforce the treatment standards presented in Section 7 of this document. Accordingly, facilities should use these procedures in assessing the performance of their treatment systems.

1.2.7 BDAT Treatment Standards for "Derived-From" and "Mixed" Wastes

(1) Wastes from treatment trains generating multiple residues. In a number of instances, the proposed BDAT consists of a series of operations, each of which generates a waste residue. For example, the proposed BDAT for a certain waste code is based on solvent extraction, steam stripping, and activated carbon adsorption. Each of these treatment steps generates a waste requiring treatment--a solvent-containing stream from solvent extraction, a stripper overhead, and spent activated carbon. Treatment of these wastes may generate further residues; for instance, spent activated carbon (if not regenerated) could be incinerated, generating an ash and possibly a scrubber water waste. Ultimately, additional wastes are generated that may require land disposal. With respect to these wastes, the Agency wishes to emphasize the following points:

1. All of the residues from treating the original listed wastes are likewise considered to be the listed waste by virtue of the derived-from rule contained in 40 CFR 261.3(c)(2). (This point is discussed more fully in (2) below.) Consequently, all of the wastes generated in the course of treatment would be prohibited from land disposal unless they satisfy the treatment standard or meet one of the exceptions to the prohibition.

2. The Agency's proposed treatment standards generally contain a concentration level for wastewaters and a concentration level for nonwastewaters. The treatment standards apply to all of the wastes generated in treating the original prohibited waste. Thus, all derived-from wastes meeting the Agency definition of wastewater (less than 1 percent total organic carbon (TOC) and less than 1 percent total suspended solids) would have to meet the treatment standard for wastewaters. All residuals not meeting this definition would have to meet the treatment standard for nonwastewaters. EPA wishes to make clear that this approach is not meant to allow partial treatment in order to comply with the applicable standard.

3. The Agency has not performed tests, in all cases, on every waste that can result from every part of the treatment train. However, the Agency's treatment standards are based on treatment of the most concentrated form of the waste. Consequently, the Agency believes that the less concentrated wastes generated in the course of treatment will also be able to be treated to meet this value.

(2) Mixtures and other derived-from residues. There is a further question as to the applicability of the BDAT treatment standards to residues generated not from treating the waste (as discussed above), but from other types of management. Examples are contaminated soil or leachate that is derived from managing the waste. In these cases, the mixture is still deemed to be the listed waste, either because of the derived-from rule (40 CFR 261.3(c)(2)(i)) or the mixture rule (40 CFR 261.3(a)(2)(iii) and (iv)) or because the listed waste is contained in the matrix (see, for example, 40 CFR 261.33(d)). The prohibition for the particular listed waste consequently applies to this type of waste.

The Agency believes that the majority of these types of residues can meet the treatment standards for the underlying listed wastes (with the possible exception of contaminated soil and debris for which the Agency is currently investigating whether it is appropriate to establish a separate treatability subcategorization). For the most part, these residues will be less concentrated than the original listed waste. The Agency's treatment standards also make a generous allowance for process variability by assuming that all treatability values used to establish the standard are lognormally distributed. The waste also might be amenable to a relatively nonvariable form of treatment technology such as incineration. Finally, and perhaps most important, the rules contain a treatability variance that allows a petitioner to demonstrate that its waste cannot be treated to the level specified in the rule (40 CFR Part 268.44(a)). This provision provides a safety valve that allows persons with unusual waste matrices to demonstrate the appropriateness of a different standard. The Agency, to date, has not received any petitions under this provision (for example, for residues contaminated with a prohibited solvent waste), indicating, in the Agency's view, that the existing standards are generally achievable.

(3) Residues from managing listed wastes or that contain listed wastes. The Agency has been asked if and when residues from managing hazardous wastes, such as leachate and contaminated ground water, become subject to the land disposal prohibitions. Although the Agency believes this question to be settled by existing rules and interpretative statements, to avoid any possible confusion the Agency will address the question again.

Residues from managing First Third wastes, listed California List wastes, and spent solvent and dioxin wastes are all considered to be subject to the prohibitions for the listed hazardous waste as originally generated. Residues from managing California List wastes likewise are subject to the California List prohibitions when the residues themselves exhibit a characteristic of hazardous waste. This determination stems directly from the derived-from rule in 40 CFR 261.3(c)(2) or, in some cases, from the fact that the waste is mixed with or otherwise contains the listed waste. The underlying principle stated in all of these provisions is that listed wastes remain listed until delisted.

The Agency's historic practice in processing delisting petitions that address mixing residuals has been to consider them to be the listed waste and to require that delisting petitioners address all constituents for which the derived-from waste (or other mixed waste) was listed. The language in 40 CFR 260.22(b) states that mixtures or derived-from residues can be delisted provided a delisting petitioner makes a demonstration identical to that which a delisting petitioner would make for the original listed waste. Consequently, these residues are treated as the original listed waste for delisting purposes. The statute likewise takes this position, indicating that soil and debris that are contaminated with listed spent solvents or dioxin wastes are subject to the prohibition for these wastes even though these wastes are not the originally generated waste, but rather are a residual from management (RCRA section 3004(e)(3)). It is EPA's view that all such residues are covered by the existing prohibitions and treatment standards for the listed hazardous waste that these residues contain or from which they are derived.

1.2.8 Transfer of Treatment Standards

EPA is proposing some treatment standards that are not based on testing of the treatment technology on the specific waste subject to the treatment standard. The Agency has determined that the constituents present in the untested waste can be treated to the same performance levels as those observed in other wastes for which EPA has previously developed treatment data. EPA believes that transferring treatment performance data for use in establishing treatment standards for untested wastes is technically valid in cases where the untested wastes are generated from similar industries or processing steps, or have similar waste characteristics affecting performance and treatment selection. Transfer of treatment standards to similar wastes or wastes from similar processing steps requires little formal analysis. However, in a case where only the industry is similar, EPA more closely examines the waste characteristics prior to deciding whether the untested waste constituents can be treated to levels associated with tested wastes.

EPA undertakes a two-step analysis when determining whether constituents in the untested wastes can be treated to the same level of performance as in the tested waste. First, EPA reviews the available waste characterization data to identify those parameters that are expected to affect treatment selection. EPA has identified some of the most important constituents and other parameters needed to select the treatment technology appropriate for the given waste(s) in Section 3.

Second, when analysis suggests that an untested waste can be treated with the same technology as a waste for which treatment performance data are already available, EPA analyzes a more detailed list of characteristics that the Agency believes will affect the performance of the technology. By examining and comparing these characteristics, the Agency determines whether the untested wastes will achieve the same level of treatment as the tested waste. Where the Agency determines that the untested waste can be treated as well or better than the tested waste, the treatment standards can be transferred.

1.3 Variance from the BDAT Treatment Standard

The Agency recognizes that there may exist unique wastes that cannot be treated to the level specified as the treatment standard. In such a case, a generator or owner/operator may submit a petition to the Administrator requesting a variance from the treatment standard. A particular waste may be significantly different from the wastes on which the treatment standards are based because the subject waste contains a more complex matrix that makes it more difficult to treat. For example, complex mixtures may be formed when a restricted waste is mixed with other waste streams by spills or other forms of inadvertent mixing. As a result, the treatability of the restricted waste may be altered such that it cannot meet the applicable treatment standard.

Variance petitions must demonstrate that the treatment standard established for a given waste cannot be met. This demonstration can be made by showing that attempts to treat the waste by available technologies were not successful or by performing appropriate analyses of the waste, including waste characteristics affecting performance, which demonstrate that the waste cannot be treated to the specified levels. Variances will not be granted based solely on a showing that adequate BDAT treatment capacity is unavailable. (Such demonstrations can be made according to the provisions in Part 268.5 of RCRA for case-by-case extensions of the effective date.) The Agency will consider granting generic petitions provided that representative data are submitted to support a variance for each facility covered by the petition.

Petitioners should submit at least one copy to:

The Administrator
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

An additional copy marked "Treatability Variance" should be submitted to:

Chief, Waste Treatment Branch
Office of Solid Waste (WH-565)
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

Petitions containing confidential information should be sent with only the inner envelope marked "Treatability Variance" and "Confidential Business Information" and with the contents marked in accordance with the requirements of 40 CFR Part 2 (41 FR 36902, September 1, 1976, amended by 43 FR 4000).

The petition should contain the following information:

1. The petitioner's name and address.
2. A statement of the petitioner's interest in the proposed action.
3. The name, address, and EPA identification number of the facility generating the waste, and the name and telephone number of the plant contact.
4. The process(es) and feed materials generating the waste and an assessment of whether such process(es) or feed materials may produce a waste that is not covered by the demonstration.
5. A description of the waste sufficient for comparison with the waste considered by the Agency in developing BDAT, and an estimate of the average and maximum monthly and annual quantities of waste covered by the demonstration. (Note: The petitioner should consult the appropriate BDAT background document for determining the characteristics of the wastes considered in developing treatment standards.)
6. If the waste has been treated, a description of the system used for treating the waste, including the process design and operating conditions. The petition should include the reasons the treatment standards are not achievable and/or why the petitioner believes the standards are based on inappropriate technology for treating the waste. (Note: The petitioner should refer to the BDAT background document as guidance for determining the design and operating parameters that the Agency used in developing treatment standards.)
7. A description of the alternative treatment systems examined by the petitioner (if any); a description of the treatment system deemed appropriate by the petitioner for the waste in question; and, as appropriate, the concentrations in the treatment residual or extract of the treatment residual (i.e., using the TCLP, where appropriate, for stabilized metals) that can be achieved by applying such treatment to the waste.
8. A description of those parameters affecting treatment selection and waste characteristics that affect performance, including results of all analyses. (See Section 3 for a discussion of

waste characteristics affecting performance that the Agency has identified for the technology representing BDAT.)

9. The dates of the sampling and testing.

10. A description of the methodologies and equipment used to obtain representative samples.

11. A description of the sample handling and preparation techniques, including techniques used for extraction, containerization, and preservation of the samples.

12. A description of analytical procedures used, including QA/QC methods.

After receiving a petition for a variance, the Administrator may request any additional information or waste samples that may be required to evaluate and process the petition. Additionally, all petitioners must certify that the information provided to the Agency is accurate under 40 CFR 268.4(b).

In determining whether a variance will be granted, the Agency will first look at the design and operation of the treatment system being used. If EPA determines that the technology and operation are consistent with BDAT, the Agency will evaluate the waste to determine if the waste matrix and/or physical parameters are such that the BDAT treatment standards reflect treatment of this waste. Essentially, this latter analysis will concern the parameters affecting treatment selection and waste characteristics affecting performance parameters.

In cases where BDAT is based on more than one technology, the petitioner will need to demonstrate that the treatment standard cannot be met using any of the technologies, or that none of the technologies are appropriate for treatment of the waste. After the Agency has made a determination on the petition, the Agency's findings will be published in the *Federal Register*, followed by a 30-day period for public comment. After review of the public comments, EPA will publish its final determination in the *Federal Register* as an amendment to the treatment standards in 40 CFR Part 268, Subpart D.

2. INDUSTRY AFFECTED AND WASTE CHARACTERIZATION

According to 40 CFR 261.32, the waste identified as K061 is specifically generated by the iron and steel industry and is defined as: emission control dust/sludge from the primary production of steel in electric furnaces. This section discusses the industry affected by the land disposal restrictions for K061 waste, describes the process generating the waste, and presents the available waste characterization data for the waste.

2.1 Industry Affected and Process Description

K061 waste is generated during the production of steel in electric furnaces. Information compiled from trade associations provides a geographic distribution of the number of electric furnace steel producers across the United States. Table 2-1 lists the number of facilities by State, while Table 2-2 summarizes the number of facilities for each EPA region. Figure 2-1 illustrates these data geographically on a map of the United States.

The primary production of steel in electric furnaces generates particulate emissions that contain hazardous constituents present in the raw materials. The particulates, which are primarily composed of iron, BDAT list metals, and other inorganics, are removed from off-gases by baghouses, venturi scrubbers, or electrostatic precipitators. The dust or sludge collected is the listed waste K061. The process that generates K061 is illustrated in Figure 2-2.

Table 2-1 Number of Producers of Steel in Electric Furnaces by State

EPA Region	State	Producers[a]
I	Connecticut	1
II	New Jersey	2
II	New York	4
III	Delaware	1
III	Maryland	2
III	Pennsylvania	24
IV	Alabama	2
IV	Florida	3
IV	Georgia	2
IV	Kentucky	3
IV	Mississippi	1
IV	North Carolina	1
IV	South Carolina	2
IV	Tennessee	1
V	Illinois	11
V	Indiana	3
V	Michigan	4
V	Minnesota	1
V	Ohio	6
VI	Louisiana	1
VI	Texas	8
VII	Montana	1
VII	Nebraska	1
VIII	Colorado	1
VIII	Utah	1
IX	Arizona	1
IX	California	3
X	Washington	3

[a] These data are based on a 1984 survey by the American Iron and Steel Institute. Of the above-listed 94 plants, it has been estimated that 10 percent, or 9 plants have closed. The estimate of 85 plants reflects this information.

Reference: American Iron and Steel Institute 1984.

Table 2-2 Number of Producers of Steel in Electric Furnaces by EPA Region

EPA Region	Producers[a]
I	1
II	6
III	27
IV	15
V	25
VI	9
VII	2
VIII	2
IX	4
X	3

[a] These data are based on a 1984 survey by the American Iron and Steel Institute. Of the above-listed 94 plants, it has been estimated that 10 percent, or 9 plants, have closed. The estimate of 85 plants reflects this information.

Reference: Directory of Iron and Steel Works of the U.S. and Canada, American Iron and Steel Institute 1984.

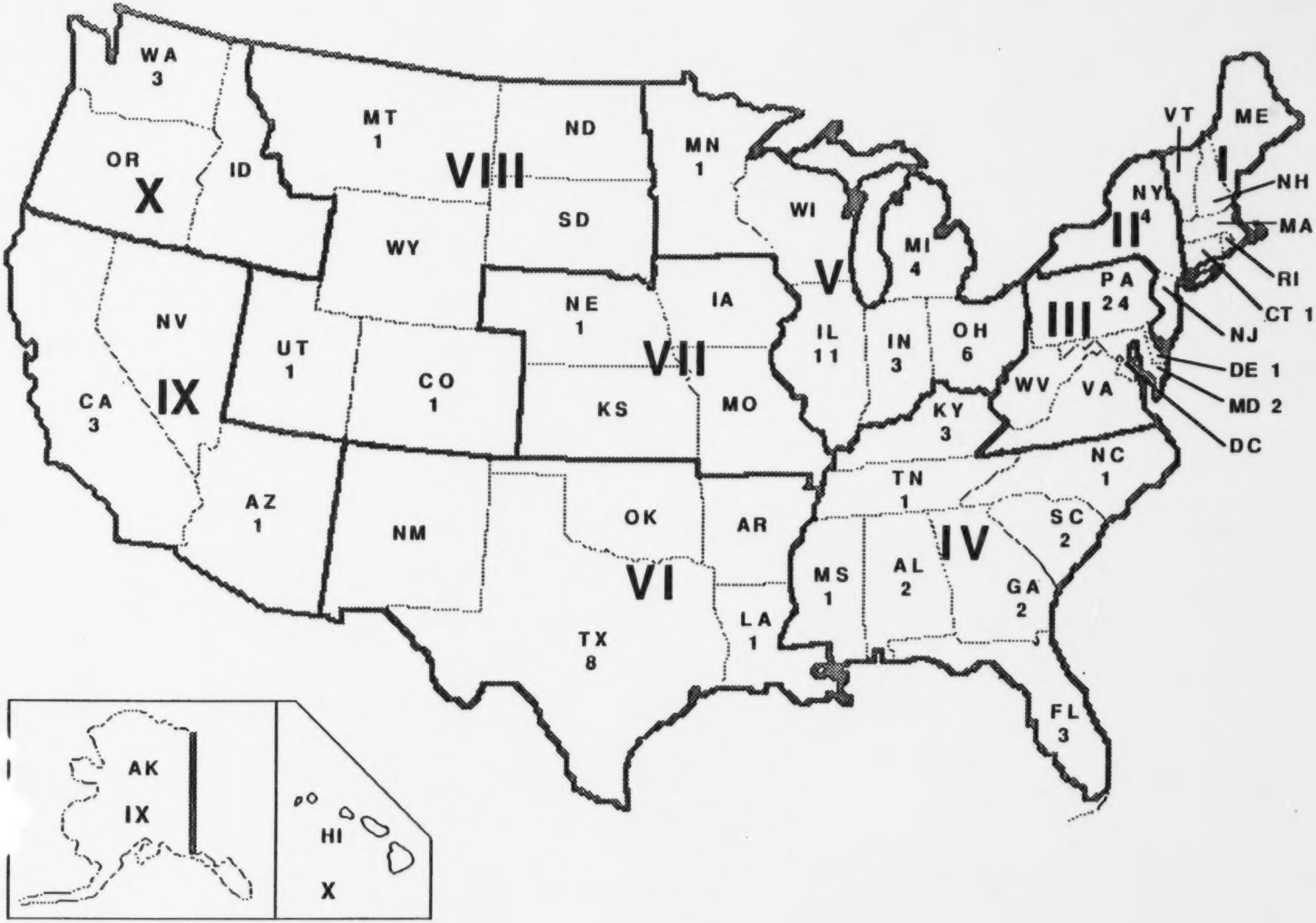
WA
3
OR
X
ID
MT
1
VIII
ND
SD
WY
MN
1
WI
V
MI
4
VT
ME
I
NY
4
II
NH
MA
RI
CT 1
NJ
PA
24
III
DE 1
MD 2
DC
NV
IX
CA
3
UT
1
CO
1
NE
1
VII
IA
KS
MO
IL
11
IN
3
OH
6
WV
VA
KY
3
NC
1
TN
1
SC
2
AZ
1
NM
OK
VI
TX
8
AR
LA
1
MS
1
AL
2
IV
GA
2
FL
3
AK
IX
HI
X

FIGURE 2-1 FACILITIES PRODUCING STEEL IN ELECTRIC FURNACES BY STATE AND EPA REGION

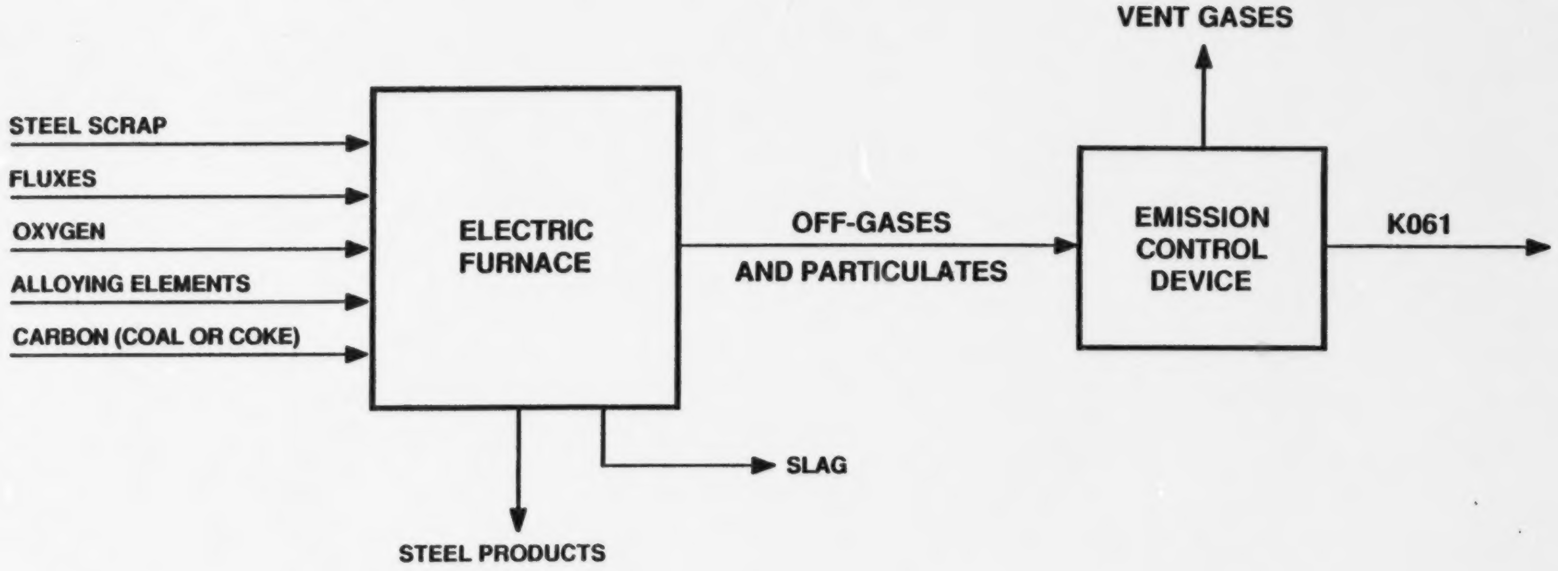
STEEL SCRAP
FLUXES
OXYGEN
ALLOYING ELEMENTS
CARBON (COAL OR COKE)
ELECTRIC FURNACE
OFF-GASES AND PARTICULATES
EMISSION CONTROL DEVICE
VENT GASES
K061
SLAG
STEEL PRODUCTS

FIGURE 2-2 STEEL PRODUCTION IN ELECTRIC FURNACES

The raw materials used in the primary production of steel in electric furnaces include steel scrap, alloying elements, coal or coke, and fluxes such as limestone or fluorspar. The type of scrap used and the alloying elements added are determined by the grade of steel being produced. Typically, steel products can be categorized into three groups: (1) specialty or stainless steels, (2) alloy steels, and (3) carbon steels. Each of these grades of steel is produced to meet defined specifications with respect to the concentration of alloying elements such as aluminum, chromium, magnesium, molybdenum, nickel, and titanium. Generally, stainless, specialty, and alloy steels contain higher concentrations of alloying elements than carbon steels. As a result of the stringent product requirements for specialty, stainless, and alloy steels, the scrap used for these steels is generally of higher quality and contains lower concentrations of undesirable impurities, such as zinc, which may be detrimental to product quality. However, for the production of carbon steel products, the use of high zinc galvanized steel scrap is a common practice.

The production of steel in electric furnaces essentially consists of four steps: (1) melting the scrap material, (2) injecting additives, (3) refining, and (4) tapping the furnaces. The feed materials are charged into a refractory-lined furnace and melted by the electric current arcing through the steel between the electrodes. The high temperature arc melts the scrap in an oxidizing atmosphere, and particulate material is generated as the undesirable elements are removed from the melt. Depending on the grade of steel being produced and the quality of scrap used, BDAT list metals, including cadmium, chromium, copper, lead, zinc, and other elements, are volatilized in the fume from the furnace.

Particulates form as a result of the oxidation, condensation, and deposition of these metals from the vapor phase onto fugitive dust. Therefore, the composition of the particulates formed varies directly with the type of steel being produced and the constituents being volatilized from the furnace. Typically, the dust generated from the production of carbon steels is higher in zinc content than the K061 waste from the production of specialty, stainless, and alloy steels. These wastes have different waste characteristics and different demonstrated treatment technologies. Accordingly, the Agency has defined two subcategories of K061 waste: (1) a high zinc subcategory (greater than or equal to 15 percent total zinc), and (2) a low zinc subcategory (less than 15 percent total zinc). The descriptions of the waste characteristics of the two subcategories of K061 waste are presented in the following section, and the applicable and demonstrated treatment technologies are described in Section 3.

2.2 Waste Characterization

This section includes all waste characterization data available to the Agency for K061 waste. Estimates of the major constituents that compose the two wastes subcategories and their approximate concentrations are presented in Tables 2-3 and 2-4. The percent concentration of each

Table 2-3 Major Constituent Composition[a]
Untreated High Zinc Subcategory K061 Waste

Major constituents	Concentration (%)
Iron	26
Oxygen (in metal oxides)	18
Zinc	16
Water	12
Calcium	7
Other elements (C,N,H)	4
Fluorides	3
Manganese	3
Lead	2
Magnesium	2
Alkali metals (Na, K)	2
Silica	2
Chlorides	2
Other BDAT metals (Cd,Cr,Cu,Ni,Ba,Hg,As,etc.)	≤ 0.5
TOTAL	100

[a] Approximate percent concentrations presented here were developed based on EPA's review of chemical analyses.

Table 2-4 Major Constituent Composition[a]
Untreated Low Zinc Subcategory K061 Waste

Major constituents	Concentration (%)
Iron	30
Oxygen (in metal oxides)	20
Chromium	7
Nickel	2
Water	6
Calcium	5
Lead	1
Magnesium	4
Manganese	3
Molybdenum	2
Alkali metals (Na, K)	4
Silica	4
Zinc	5
Fluorides	2
Other BDAT metals (Cd,Cu,Ba,Hg,As,etc.)	$\leq$4
TOTAL	100

[a] Approximate percent concentrations presented here were developed based on EPA's review of available data in literature sources.

major constituent in the waste was determined by best estimates based on chemical analyses and review of available waste characterization data from the literature.

Below is a discussion of the two sources of waste characterization data from which most of the Agency's data on waste characteristics for each subcategory were obtained. Other sources were not as useful because the data were incomplete or it was not possible to determine the origin of the waste with respect to the grade of steel produced. The two sources of waste characterization data for which the discrete source of the waste could be determined were used to estimate the major constituents of the two subcategories of K061. These sources of data were: (1) Characterization, Recovery, and Recycling of Electric Furnace Dust, prepared by Lehigh University for the Department of Commerce, and (2) EPA's testing programs. The Lehigh University report contains 34 data points from 25 facilities producing a variety of specialty, alloy, and carbon steel products. EPA waste characterization data for K061 waste were compiled from three sources: the Onsite Engineering Report for Horsehead Resource Development Co., Inc. for K061 (7 data points for K061 wastes from carbon steel production); the Onsite Engineering Report for Waterways Experiment Station for K061 (1 data point for K061 wastes from carbon steel production); and the EPA Office of Solid Waste Relisting Program sampling/analysis activities from K061 (7 data points for K061 from carbon steel production and 2 data points for K061 wastes from specialty steel production). In total, 51 data points were identified, with 13 of these points originating from specialty, stainless, and/or mixed alloy steel production operations.

Tables 2-5, 2-6, and 2-7 represent waste characterization data for both subcategories of K061 wastes collected from 18 literature sources. In general, these data are summarized as ranges or as averages of several samples for these tables. Table 2-7 shows leachate concentrations (EP and TCLP) of the untreated K061 waste. The data presented display the variation in concentrations of BDAT list metals found in K061 wastes from different generators producing different grades of steel products. An examination of these data indicates that the K061 wastes from stainless, specialty, and alloy steel production are significantly different from the K061 wastes from carbon steel production. The differences are most notable with respect to the zinc, chromium, and nickel content of the wastes. In general, the zinc content for K061 wastes from specialty and stainless steel production averages in the 3 to 5 percent range, while the zinc content for K061 wastes from carbon steel production generally ranges from 15 to 30 percent. Also, the chromium concentration in specialty, stainless, and alloy steel wastes is approximately 7 percent, and in carbon steel wastes it is less than 1 percent. The data also indicate that nickel is more prevalent in specialty and stainless K061 wastes.

Table 2-5 BDAT Constituent Composition and Other Data - Untreated High Zinc Subcategory K061 Waste

BDAT constituent	Total concentration (ppm) Source of data: (a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Antimony	52-89	294	-	BDL	-	-	50-150	-	-
Arsenic	42-127	36	-	140-305	46.7	40	<100-400	-	-
Barium	164-204	238	-	24-369	-	400	-	-	-
Beryllium	<0.5-1.5	0.15	-	0.5	-	-	-	-	-
Cadmium	290-857	481	280	64-1,100	370	600	200-900	600	12.4-4,988
Chromium	803-1,190	1,370	2,000	800-12,200	426.6	1,100	400-500	3,900	600-5,390
Copper	1,460-2,640	2,240	1,900	486-2,520	-	-	1,500-2,000	-	-
Lead	14,900-21,900	20,300	19,900	7,290-25,800	11,133	38,000	24,000-50,000	4,500	533-139,000
Mercury	1.0-2.0	3.8	-	-	-	2	7-41	-	0.0002-5.26
Nickel	184-449	243	300	39-6,870	-	<10	1,000-3,000	-	133-1680
Selenium	5.2-20	<5.0	-	-	-	<50	-	-	-
Silver	23-44	59	-	2.5-65	-	-	-	-	-
Thallium	0.75-2.7	<1.0	-	-	-	50	-	-	-
Vanadium	24-37	25	-	39-138	-	-	-	-	-
Zinc	129,000-155,000	244,000	150,000	32,600-257,000	186,000	167,000	150,000-320,000	188,000	4,360-236,000
Water (%)	12%	-	-	-	-	-	-		-
Total Organic Carbon	<1%	-	-	-	-	-	-		-

- = No data.

(a) Reference: USEPA 1987b.
(b) Reference: USEPA 1988.
(c) Reference: USDOC 1982.
(d) Reference: USEPA 1987a.
(e) Reference: Raritan River Steel, Delisting Petition.
(f) Reference: Bethlehem Steel, Delisting Petition.
(g) Reference: SKF Plasmadust.
(h) Reference: Sumitomo Molten Slag.
(i) Reference: St. Joe Flame Reactor.

Table 2-6 BDAT Constituent Composition and Other Data - Untreated Low Zinc Subcategory K061

BDAT constituent	Total concentration (ppm) Source of data: (a)	(b)	(c)	(d)	(e)	(f)	(g)
Antimony	-	-	96-137	-	-	-	-
Arsenic	-	-	206-264	-	-	-	-
Barium	-	-	32-299	-	-	-	-
Beryllium	-	-	0.72-1.6	-	-	-	-
Cadmium	520	490	88-380	100-600	-	-	-
Chromium	106,000	3,900	2,080-14,800	60,000-100,000	1,380	2,690	-
Copper	5,400	1,700	1,610-6,360	600-3,000	-	-	1,200
Lead	9,400	25,800	10,800-14,200	6,000-14,000	24,220	7,900	1,400
Mercury	-	-	-	0.7-16	-	-	-
Nickel	22,000	900	206-16,200	15,000-22,000	-	-	5,900
Selenium	-	-	-	-	-	-	-
Silver	-	-	21-71	-	-	-	-
Thallium	-	-	-	-	-	-	-
Vanadium	-	-	170-475	-	-	-	-
Zinc	27,500	137,000	88,200-93,800	22,000-53,000	-	-	3,900
Water (%)	-	-	-	-	-		
Total Organic Carbon	-	-	-	-	-		

- = No data.

(a) Reference: USDOC 1982.
(b) Reference: USDOC 1982.
(c) Reference: USEPA 1987a.
(d) Reference: SKF Plasmadust.
(e) Reference: USEPA 1980a.
(f) Reference: USEPA 1980a.
(g) Reference: USEPA 1980a.

Table 2-6 (Continued)

BDAT constituent	Total concentration (ppm) Source of data:						
	(a)	(b)	(c)	(d)	(e)	(f)	(g)
Antimony	-	-	-	-	5.03	-	-
Arsenic	470	-	-	10.2	58.7	-	-
Barium	-	-	-	61.4	205	-	41.9
Beryllium	-	-	-	-	8.08	-	-
Cadmium	1,000	-	1.35	293	1,053	682	13.1
Chromium	25,900	1,380	<0.05	848	1,053	1,029	354
Copper	-	-	-	742	-	-	-
Lead	14,600	24,200	1.29	8,967	40,275	15,875	1,495
Mercury	-	-	-	0.059	15.1	-	0.038
Nickel	-	246	-	137	152.3	-	-
Selenium	600	-	-	1.03	590	-	0.068
Silver	-	-	-	14.5	39.5	-	-
Thallium	-	-	-	-	<10	-	-
Vanadium	-	-	-	-	46.5	-	-
Zinc	-	95,710	-	71,333	-	-	-

- = No data.

(h) Reference: U.S. Bureau of Mines 1983.
(i) Reference: Calspan Corporation 1977.
(j) Reference: Harrison Steel Casting, Delisting Petition.
(k) Reference: U.S. Steel, Delisting Petition.
(l) Reference: Stablex Corp, Delisting Petition.
(m) Reference: Marathon Steel, Delisting Petition.
(n) Reference: McClouth Steel, Delisting Petition.

Table 2-7 Untreated K061 Leachate Data

Leachate test	Ag (mg/l)	As (mg/l)	Ba (mg/l)	Cd (mg/l)	Cr (mg/l)	Pb (mg/l)	Se (mg/l)	Hg (mg/l)
EP[a]	<0.1	0.009	<0.5	37.5	<0.1	20	0.021	0.030
EP[a]	<0.1	0.004	1.3	0.3	<0.1	<0.5	0.017	0.003
EP[a]	<0.1	0.022	1.7	13.4	<0.1	64.5	0.032	0.002
EP[a]	<0.1	0.012	2.1	5.0	5.0	<0.5	0.114	0.025
EP[a]	<0.1	0.007	<0.5	0.32	16.5	<0.5	0.99	0.002
EP[a]	<0.1	0.012	13.5	<0.03	0.7	40	0.017	0.007
EP[a]	<0.1	0.008	<0.8	24.3	<0.1	39	0.016	0.002
EP[a]	<0.1	0.006	3.2	6.3	4.3	<0.5	0.132	0.001
EP[a]	<0.1	0.003	5.3	8.4	<0.1	64.5	0.023	0.007
EP[a]	<0.1	0.017	<0.8	1.9	47.2	<0.5	0.024	0.684
EP[a]	<0.1	0.002	<0.8	2.7	0.2	8.8	0.005	0.006
EP[a]	<0.1	0.014	0.9	<0.03	<0.1	<0.06	<0.004	0.004
EP[a]	<0.1	0.017	<0.5	<0.03	0.6	33	0.450	0.007
EP[a]	<0.1	0.005	<0.5	<0.03	<0.1	<0.5	0.005	<0.0002
EP[a]	<0.1	0.021	<0.5	8.2	<0.1	34.5	0.024	0.012
EP[a]	<0.1	0.016	1.7	4.6	<0.1	<0.5	0.530	0.001
EP[a]	<0.1	0.035	<0.5	7.9	<0.1	40	0.071	0.002
EP[a]	<0.1	0.015	<0.5	630	71	<0.5	0.205	0.035
EP[a]	<0.1	0.025	<0.5	6.0	<0.1	21.5	0.026	0.004
EP[a]	<0.1	0.013	2.8	2.6	<0.1	95	<0.004	0.004
EP[a]	<0.1	0.019	<1.0	4.0	<0.2	21	0.034	0.017
EP[a]	<0.1	0.011	2.8	26	<0.1	23.5	0.019	0.016
EP[a]	<0.1	0.020	3.1	<0.03	1.1	1.5	0.052	0.005
EP[a]	<0.1	0.008	<0.8	6.3	<0.1	51	0.324	0.007
EP[a]	<0.1	0.009	<0.8	70.7	0.2	2.6	0.080	<0.0002
EP[a]	<0.1	0.009	<0.8	6.3	<0.1	35	0.026	0.004
EP[a]	<0.1	0.019	1.5	1.7	<0.2	19.3	0.007	0.014
EP[a]	<0.1	0.009	<1.0	6.5	7.6	1.0	0.104	0.027
EP[a]	<0.1	0.010	2.5	<0.1	216	<0.5	0.386	0.005
EP[a]	<0.1	0.011	2.1	1.2	26	<0.5	0.631	0.094
EP[a]	<0.1	0.022	<1.0	4.4	<0.2	21.1	0.315	0.006
EP[a]	<0.1	0.011	<0.5	7.2	1.2	23.9	0.033	0.016

Table 2-7 (Continued)

Leachate test	Ag (mg/l)	As (mg/l)	Ba (mg/l)	Cd (mg/l)	Cr (mg/l)	Pb (mg/l)	Se (mg/l)	Hg (mg/l)
TCLP[b]	0.021	<0.010	0.733	12.8	<0.007	45.1	<0.05	0.0026
TCLP[c]	<0.025	<0.095	0.130	2.850	0.055	<0.300	<0.100	0.0047
TCLP[c]	<0.005	<0.019	0.658	33.200	<0.030	22.5	0.045	0.0028
TCLP[c]	<0.025	<0.095	0.785	0.015	0.282	61.2	0.016	0.0031
TCLP[c]	<0.025	<0.095	1.200	1.330	<0.030	16.100	0.050	<0.002
TCLP[c]	<0.025	<0.095	0.376	0.019	0.227	0.330	0.193	<0.002
TCLP[c]	<0.025	<0.095	0.883	3.880	<0.030	28.2	<0.005	<0.002
TCLP[c]	<0.025	<0.095	1.580	2.580	<0.030	1.550	<0.025	<0.002
TCLP[c]	<0.025	<0.095	0.657	1.260	<0.030	12.4	<0.025	<0.002
TCLP[c]	<0.025	<0.095	0.290	<0.015	9.050	<0.330	<0.050	<0.002

[a] All EP data from Characterization, Recovery, and Recycle of EAF Dusts, Lehigh University.

[b] TCLP data from Onsite Engineering Report for Waterways Experiment Station for K061.

[c] TCLP data for EPA/OSW Relisting Program EAF Dust Analysis.

3. APPLICABLE/DEMONSTRATED TREATMENT TECHNOLOGIES

This section describes the applicable treatment technologies identified for both subcategories of K061 waste. Included in this section are discussions of those applicable treatment technologies that have also been demonstrated on a commercial basis for the two subcategories of K061 waste.

3.1 Applicable Treatment Technologies

Initial data gathering on the treatment of K061 waste included telephone contacts with the American Iron and Steel Institute (AISI), identification of generators from EPA's Hazardous Waste Data Management Systems (HWDMS), contacts with EPA's Office of Solid Waste Relisting Program, and compilation of available technical publications on electric furnace steel production and K061 treatment.

From these sources, the technologies that the Agency has identified as being applicable to K061 waste are designed to treat the BDAT list metal constituents in high filterable solids matrices. They include direct and indirect recycle, high temperature metals recovery, hydrometallurgical extraction (leaching), and stabilization. All of these technologies, to varying extents, reduce the concentration and/or leachability of the BDAT list metals present in the treated residual. A brief description of each technology follows:

- Recycling of K061 directly back into the electric furnace from which it was originally produced facilitates the recovery of the metals for steel making, while reducing or eliminating the material to be land disposed.

- High temperature metals recovery is similar to recycle in that it is used to recover metals from the K061 for reuse, and reduces the concentration, leachability, and volume of waste to be land disposed.
- Leaching removes certain metals from wastes based on the relative solubilities of the metal compounds contained in the wastes.
- Stabilization reduces the leachability of metals from the waste prior to land disposal.

3.2 Demonstrated Treatment Technologies

To determine which technologies are demonstrated for K061 wastes, EPA first compiled, from the information sources listed above, a list of facilities that were potential users of these technologies on a full-scale basis. This effort included telephone contacts to several K061 generators and several commercial treatment facilities.

Of the applicable technologies listed above, EPA has not been able to identify any instances where recycling or leaching have been successfully applied to K061, or any similar waste, on a commercial scale. The Agency therefore concludes that neither of these technologies--recycling or leaching--could qualify as a demonstrated technology for K061 waste. This leaves only high temperature metals recovery and stabilization as potentially demonstrated technologies for this waste.

The Agency is aware of at least four facilities in the United States, and ten in foreign countries, that use high temperature metals recovery on a full-scale basis; these facilities treat emission control dust or sludge from primary steel production in electric furnaces. The

14 facilities employ five different treatment processes for these wastes: the rotary kiln process, rotary hearths/electric furnaces, plasma arc reactors, molten slag reactors, and flame reactor systems.

The wastes typically treated by all these high temperature metals recovery processes tend to be high in zinc. The Agency believes, on the basis of available data and industry experience, that the range of zinc concentrations in K061 wastes from production of different grades of K061 may not allow the use of high temperature metals recovery on all K061 wastes. In some instances, the initial zinc content may be too low for effective upgrading by any of the five high temperature metals recovery processes identified in full-scale operation. An examination of available treatment performance data from EPA's testing of the rotary kiln process of high temperature metals recovery indicates the minimum feed concentration for zinc was 12.9 percent, while the mean was 14 percent. Other data sources are consistent with this result; they report 15 percent as a minimum feed concentration. The Agency has therefore determined that it is appropriate to establish 15 percent zinc as a concentration threshold in K061 waste at which high temperature metals recovery is demonstrated.

EPA has data indicating that stabilization is used by a number of facilities to treat K061 wastes. In addition, stabilization is a broadly applicable and commercially demonstrated technology for reducing the leachability of BDAT metals from residuals that are land disposed.[*] The Agency therefore concludes that stabilization is a demonstrated technology for all K061 wastes.

3.2.1 High Temperature Metals Recovery

High temperature metals recovery (HTMR) provides for recovery of metals from wastes primarily by volatilization of the metals to be recovered, subsequent condensation from the gas phase, and product collection steps. The process yields metal products for reuse and substantially reduces the concentration of metals in the residual. This process also reduces the volume of waste that requires land disposal.

(1) Applicability and use of high temperature metals recovery. This process is applicable to the treatment of wastes containing BDAT list metals, low to moderate water content (or a water content that can either be blended to the required level or lowered by dewatering), and low concentrations of organics. It is applicable to a wide variety of metals, including cadmium, chromium, lead, mercury, nickel, and zinc, even though it has generally only been demonstrated on K061 wastes having initial zinc concentrations of at least 15 percent. The five high temperature metals recovery processes that have been demonstrated for K061 are the rotary kiln process, rotary hearth/electric furnace, the plasma arc reactor, the molten slag reactor, and flame reactor systems.

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[*] Additionally, several facilities are performing stabilization of K061 nonwastewater.

Also generated are treatment residuals that have reduced BDAT list metals concentration and low leachability. In some cases, however, the treatment residual (slag) can be drastically reduced in volume or even eliminated. This can occur if the iron content is converted to the metallic form rather than the oxide form and can be recycled to steel production as feed material. High temperature metals recovery is particularly applicable because it is a resource recovery technology, which is consistent with EPA's desire to reduce the land disposal of hazardous waste.

(2) Underlying principles of operation. The theory of operation of high temperature metals recovery is that sufficient heat is transferred to the waste to separate metal constituents through volatilization in a reducing atmosphere. The volatile metals can then be recovered for reuse. An example of the chemical reduction reaction would be:

$$2ZnO + C \rightarrow 2Zn + CO_2.$$

In some cases, multiple products may be collected from high temperature metals recovery if the waste contains not only BDAT list metal constituents that can be volatilized but also nonvolatile BDAT list metals as well.

In the first processing step, the metal oxides are reduced to their metallic form in the presence of carbon, which is provided in the form of coal or coke. Heat transfer is externally supplied by burning fossil fuels (natural gas, coal, coke, etc.), electricity, or molten slag from other steel production operations. In some cases, the reaction can be exothermic and may only need enough energy to initiate the reaction. Once reduced to their metallic form, the volatile metals, primarily cadmium, zinc, and lead, escape from the other feed materials. The gaseous metals may be reoxidized and collected in a baghouse or wet scrubber, or they may be condensed and recovered in the metallic form. There is no difference between these two types of metal product recovery systems relative to the kinds of waste that can be treated; the difference is simply reflected in a facility's preference relative to product purity. In the former case, the direct condensation of metals, while more costly, allows for the separation and collection of metals in a relatively uncontaminated form; in the latter case, the metals are collected as a combination of several metal oxides. If necessary, this combination of metal oxides could be further processed to produce individual metal products of increased purity.

The fraction of the waste that is not originally volatilized has three possible dispositions: (1) the material is such that it can be used directly as a product (e.g., a waste residual containing mostly metallic iron can be reused directly in steel making); (2) the material can be reused after further processing (e.g., a waste residual containing oxides of iron, chromium, and nickel can be reduced to the metallic form and then recovered for use in the manufacture of stainless steel); and (3) the material has no recoverable value and is land disposed as a slag.

(3) Description of high temperature metals recovery processes. These processes consist of four operations: (1) a blending operation to control feed parameters, (2) high temperature processing, (3) volatile product collection systems, and (4) handling of the less volatile treated residual. As stated previously, the five high temperature metals recovery systems operate on similar principles. Many steps and operations are present in all of these systems and will be described generally. Areas that differ in their design, operation, or equipment used, will be discussed separately. A generic schematic diagram for high temperature metals recovery is shown in Figure 3-1.

K061 waste in the form of a baghouse dust or a sludge from a wet scrubber can be treated by high temperature metals recovery. In some cases, it may be necessary to reduce the water content of the waste prior to treatment. This can be accomplished mechanically or by blending wastes.

Variations in feeds can be minimized by blending various wastes from different sources or from different batches of steel production over time. Prior to feeding the kiln, fluxing agents and carbon are added to the waste as required. Carbon is supplied as the reducing agent to convert metal oxides to a metallic state. The fluxes (limestone or sand) and other additives may be blended with the waste to improve the recovery of volatile metals. In some cases, these feeds are pelletized prior to processing, while in others they may be input directly to the process.

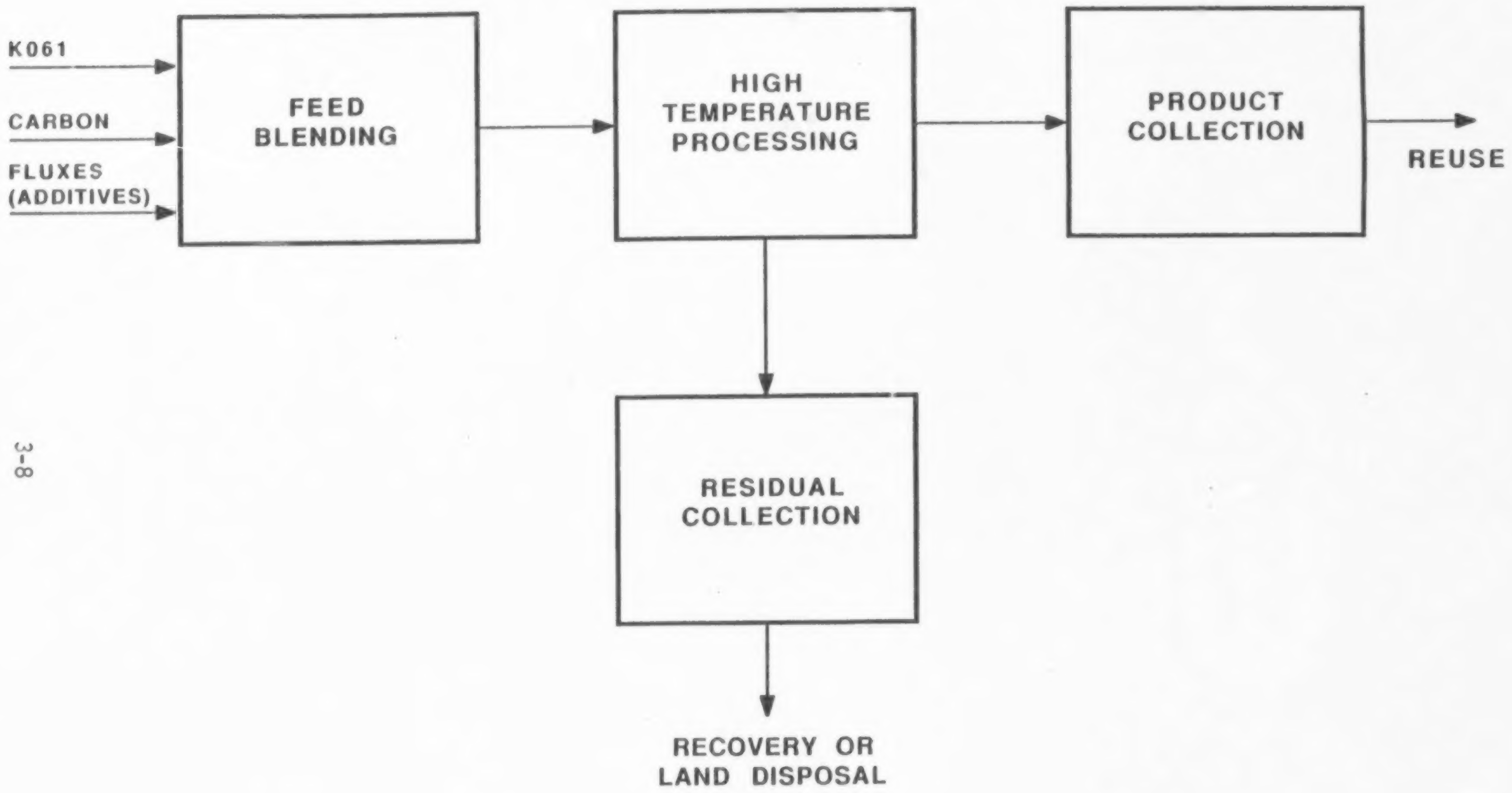
K061
CARBON
FLUXES (ADDITIVES)
FEED BLENDING
HIGH TEMPERATURE PROCESSING
PRODUCT COLLECTION
REUSE
RESIDUAL COLLECTION
RECOVERY OR LAND DISPOSAL

FIGURE 3-1 EXAMPLE HIGH TEMPERATURE METALS RECOVERY SYSTEM

Below are descriptions of the five demonstrated high temperature metals recovery processes: (a) rotary kiln process, (b) plasma arc reactor, (c) rotary hearth/electric furnace, (d) molten slag reactor system, and (e) flame reactor.

(a) Rotary kiln process. The rotary kiln process was designed to treat zinc-bearing ores and has been adapted to recover zinc from electric furnace dust (K061). The feed materials (K061, coal, fluxes) are blended and input to the kiln where they are heated and the reduction reactions begin. Volatile metals, including zinc, cadmium, and lead, are removed from the waste and concentrated in a zinc rich product. These volatile metals can be collected as oxidized particulates or can be condensed and collected in the metallic form. In some rotary kiln processes, an air stream is fed into the kiln countercurrent with the waste. The air stream flowing through the kiln provides the means to physically separate the product from the slag. As the volatile metals escape from the kiln, they are reoxidized and condensed in the air stream as particles. The enriched metal oxide particles are swept out of the kiln in the air stream and are collected in a baghouse as a product. This material is sent for further refining to produce a final zinc product.

The residual slag exits the kiln, is quenched by water, and is collected. High evaporation rates of quench water result in a net loss of water and eliminate the need for wastewater discharge. The slag, now being reduced in both volume and concentration of BDAT list metals, is sometimes land disposed, although it can be recycled back to steel production if the iron is sufficiently converted to a metallic state.

(b) Plasma arc reactor. The plasma arc process is designed to recover zinc, lead, cadmium, chromium, and iron from electric furnace dust. The feed (K061, coal, and fluxes) is fed into the lower section of a shaft furnace where the metals are reduced in the presence of coal. The high temperatures generated by the plasma arc vaporize the more volatile metals such as zinc, lead, and cadmium, which are condensed and collected as products. In addition, an iron product is generated by the process and is recycled to steel producers. The process also generates a slag and sludge.

(c) Rotary hearth/electric furnace process. The rotary hearth/electric furnace process is designed to recover a product containing iron, chromium, and nickel for reuse in specialty steel making, as well as a zinc product. The waste is pelletized with coal or coke prior to treatment. The treatment process primarily consists of two treatment steps: (1) reducing metallic oxides and volatilizing zinc and lead in a rotary hearth and (2) producing the final iron product in an electric furnace. The function of the rotary hearth is similar to that of the rotary kiln. Metallic oxides are reduced and a volatile product containing zinc and lead is recovered in a wet scrubber for reuse. The remaining metal is then resmelted in an electric furnace. During this second step, the metals volatilized from the waste are collected in a baghouse, and the zinc and lead are recovered for reuse. The iron product (containing chromium and nickel) is cast into ingots and recycled to steel producers. A slag, which requires land disposal, is generated from the process.

(d) Molten slag reactor system. The molten slag reactor system is designed to recover zinc from electric furnace dust through high temperature reduction and volatilization. The K061 waste is pelletized with coal and injected into a molten slag, which supplies the heat for reduction and volatilization. The coal serves as the reducing agent and special additives are included to improve product recovery. Auxiliary heat can be supplied if necessary. A zinc oxide product is collected in a baghouse for reuse and the remaining slag is land disposed.

(e) Flame reactor. The flame reactor is a carbon-fueled flash smelting process designed to recover zinc and lead from electric furnace dust/sludge. In the reactor, coke is mixed with oxygen at high temperatures. The K061 waste is directly injected into the reactor where the metals are reduced. The volatile metals (zinc, lead, cadmium) are collected with a baghouse and a residual slag is also generated. Generally, this slag is land disposed.

(4) Waste characteristics affecting performance. Consistent with the theory of its design, the waste characteristics that affect high temperature metals recovery are those that inhibit volatilization of metals from the waste and the recovery of metallic products. In determining whether high temperature metals recovery technologies are

likely to achieve the same level of performance on an untested waste as on a previously tested waste, EPA will examine the following three waste characteristics that have an impact on treatability: (a) type of metals in the waste, (b) relative volatility of the metals, and (c) heat transfer characteristics of the waste.

(a) Type of metals in the waste. Because this is a metals recovery process, the products must meet certain requirements for reuse. The purity of the product is a direct function of the constituents in the waste and their relative volatilities. If the waste contains other metals that are difficult to separate and whose presence may affect the ability to refine the products for reuse, high temperature metals recovery may provide less effective treatment. The metal constituents that compose K061 waste can be analyzed by EPA Method 6010 from SW-846.

(b) Volatility. The relative volatilities of the metals in the waste also affect the ability to separate various metals. Depending on the composition of the waste, the high temperature metals recovery system used, and the metal constituents being recovered, different metals will be concentrated in the volatile products and the residual slag. As a result, undesirable metals may be present in products if their volatilities are similar. There is no conventional measurement technique for determining the relative volatility of metal constituents in a given waste. EPA believes that the best measure of volatility of a given constituent is the boiling point. EPA recognizes that boiling point has certain shortcomings, primarily the fact that boiling points are given for pure components, while clearly the other constituents in the waste will affect partial pressures and thus the boiling point of the mixture. EPA has not identified a parameter that can better assess relative volatility. Boiling points of metals can be found in a variety of scientific handbooks.

(c) Heat transfer characteristics. The ability to heat and volatilize constituents within a waste matrix is a function of the heat transfer characteristics of a heterogeneous waste material. The constituents being volatilized from the waste must be heated near or above their boiling points in order to be volatilized and recovered. Within a given treatment unit, whether sufficient heat will be transferred to the particular constituent to cause the metal to volatilize will depend on the heat transfer characteristics of the waste. There is no conventional direct measurement of the heat transfer characteristics of a waste. EPA believes that the best measure of the heat transfer characteristics of the waste is thermal conductivity. The analytical method that EPA has identified for measurement of thermal conductivity is named "Guarded, Comparative, Longitudinal Heat Flow Technique"; it is described in Appendix E.

(5) Design and operating parameters. Consistent with the theory of operation, these processes are designed so that sufficient heat is transferred to the waste to ensure that the volatile metal constituents can be removed from the waste. The parameters that EPA will evaluate when determining whether a high temperature metals recovery system is

well designed and well operated are (1) the furnace temperature, (2) the furnace residence time, (3) the amount and ratio of the feed blending materials, and (4) mixing. Below is an explanation of why EPA believes these parameters are important to an analysis of the design and operation of the system.

(a) Furnace temperature. In order for volatilization to occur, sufficient heat must be transferred to the waste. The treatment system must be designed to provide high temperatures for reduction and volatilization. The higher the temperature, the more likely it is that the constituents will react with carbon to form free metals and volatilize. The volatility of the metals in the waste and the metals to be recovered thus determine the specific temperature for the system. Excessive temperatures may volatilize less volatile, undesirable metals into the product, inhibiting its potential for reuse. If the temperature is low, incomplete vaporization of volatile metals may occur, resulting in poor recoveries of metals from the waste. In assessing treatment performance, continuous temperature monitoring data are important.

(b) Furnace residence time. The system must be designed to ensure that the waste has sufficient time to be heated to a temperature whereby the metals will be volatilized. The residence time necessary for complete volatilization of these constituents is dependent upon the system temperature and the heat transfer characteristics of the waste. In practice, the residence time is a function of the physical dimensions of the system (length, diameter) and the feed rate. For the rotary kiln and rotary hearth/electric furnace systems, the rate of rotation also impacts residence time. The molten slag reactor system is a batch process and residence time is controlled by the system operator.

(c) Amount and ratio of feed blending materials. High temperature metals recovery systems must be designed with respect to the waste being treated so that metals recovery is successfully accomplished. Uniform feed conditions with regard to metals content, water content, carbon content, and calcium-to-silica ratio must be provided for the most effective treatment. Then parameters affect the rate of reduction and volatilization of metals. The system can be designed for the treatment of a particular waste, or various wastes can be blended together to minimize variations in feed composition. Different wastes may be blended from several sources or over time from steel production at one facility. Additionally, coal, fluxes, and other additives must be blended with the waste to attain the proper feed conditions. Blending ratios during treatment must be monitored to ensure that they comply with the design values for the unit.

(d) Mixing. The system must mix the waste sufficiently so that the material is uniformly heated and is exposed to the surface so that the metal constituents can volatilize. Accordingly, EPA will examine the type and degree of mixing involved when assessing treatment design and performance. In the case of the rotary kiln process and the rotary kiln/electric furnace system, this turbulence is provided by the rotary motion and depends on the rate of rotation. Mixing in the plasma arc process is provided by the injection system, which delivers a fine, granular feed material into the furnace by pressurized air. Oxygen injected into the molten slag bath provides turbulence in the molten slag reactor.

3.2.2 Stabilization

Stabilization refers to a broad class of treatment processes that chemically reduce the mobility of hazardous metal constituents in a waste. Solidification and fixation are other terms that are sometimes used synonymously for stabilization or to describe specific variations within the broader class of stabilization. Related technologies are encapsulation and thermoplastic binding; however, EPA considers the technologies to be distinct from stabilization in that the operational principles are significantly different.

(1) Applicability and use of stabilization. Stabilization is used when a waste contains metals that will leach from the waste when it is contacted by water. In general, this technology is applicable to wastes containing BDAT list metals and having a high filterable solids content, low TOC content, and low oil and grease content. Stabilization has generally been applied to electric furnace dust (K061) to reduce the leachability of hazardous metal constituents. This technology does not destroy, recover, or otherwise change the waste constituents, but is used to prevent metals from leaching.

(2) Underlying principles of operation. The basic principle underlying this technology is that stabilizing agents and other chemicals are added to a waste to minimize the amount of metal that leaches. The

reduced leachability is accomplished by the formation of a lattice structure and/or chemical bonds that bind the metals to a solid matrix and thereby limit the amount of constituents that can be leached when water or a mildly acid solution comes into contact with the material.

The two principal stabilization processes used are the cement-based process and the lime/pozzolan-based process. A brief discussion of each is provided below. In both cement-based and lime/pozzolan-based techniques, the stabilizing process can be modified through the use of additives, such as silicates, that control curing rates or enhance the properties of the solid material.

(a) Portland cement-based process. Portland cement is a mixture of powdered oxides of calcium, silica, aluminum, and iron, produced by kiln burning of materials rich in calcium and silica at high temperatures (i.e., 1,400 to 1,500°C). When the anhydrous cement powder is mixed with water, hydration occurs and the cement begins to set. The chemistry involved is complex because many different reactions occur, depending on the composition of the cement mixture.

As the cement begins to set, a colloidal gel of indefinite composition and structure is formed. Over a period of time, the gel swells and forms a matrix composed of interlacing, thin, densely packed silicate fibrils. Constituents present in the waste slurry, e.g., hydroxides and carbonates of various heavy metals, are incorporated into the interstices of the cement matrix. The high pH of the cement mixture tends to keep metals in the form of insoluble hydroxide and carbonate salts. It has been hypothesized that metal ions also may be incorporated into the crystal structure of the cement matrix, but this hypothesis has not been verified.

(b) Lime/pozzolan-based process. Pozzolan, which contains finely divided, noncrystalline silica (e.g., fly ash or components of cement kiln dust), is a material that is not cementitious in itself but becomes so upon the addition of lime. Metals in the waste are converted to silicates or hydroxides, which inhibit leaching. Additives, again, can be used to reduce permeability and thereby further decrease leaching potential.

(3) Description of stabilization processes. In most stabilization processes, the waste, stabilizing agent, and other additives, if used, are mixed and then pumped to a curing vessel or area and allowed to cure. The actual operation (equipment requirements and process sequencing) will depend on several factors such as the nature of the waste, the quantity of the waste, the locations of the waste, the curing rate, the disposal site location, the physical characteristics of the site, the particular stabilization formulation to be used, and the curing rate. After curing, the solid formed is recovered from the processing equipment and stripped for final disposal.

In instances where waste contained in a lagoon is to be treated, the material should be first transferred to mixing vessels where stabilizing agents are added. The mixed material is then fed to a curing pad or vessel. After curing, the solid formed is removed for disposal.

Equipment commonly used also includes facilities to store waste and chemical additives. Pumps can be used to transfer liquid or light sludge wastes to the mixing pits and pumpable uncured wastes to the curing site. Stabilized wastes are then removed to a final disposal site.

Commercial concrete mixing and handling equipment can generally be used with wastes. Weighing conveyors, metering cement hoppers, and mixers similar to concrete batching plants have been adapted in some operations. Unless severe corrosion occurs, no adaptation of equipment is required. Where extremely dangerous materials are being treated, remote control and in-drum mixing equipment, such as that used with nuclear waste, can be employed.

(4) Waste characteristics affecting performance. In determining whether stabilization is likely to achieve the same level of performance on an untested waste as on a previously tested waste, the Agency will focus on the characteristics that inhibit the formation of either the chemical bonds or the lattice structure. The five characteristics EPA has identified as affecting treatment performance are: (1) other metals and their concentrations, (2) fine particulates, (3) oil and grease, (4) organic compounds, and (5) inorganic compounds (including sulfates and chlorides).

(a) Other metals and their concentrations. When a waste contains a mixture of metals, it may not be possible to chemically stabilize the waste in a manner that optimizes the reduction in leachability for all constituents. The extent to which synergistic effects impact performance will depend on the type and concentration of other metals in the waste. The individual metals present and their concentrations can be measured by EPA Method 6010.

(b) Fine particulates. For both cement-based and lime/pozzolan-based processes, the literature states that very fine, insoluble materials (i.e., those that pass through a No. 200 mesh sieve, 74 um particle size) can weaken the bonding between waste particles and cement by coating the particles. This coating can inhibit chemical bond formation and thereby decrease the resistance of the material to leaching. Particle size can be measured by ASTM Method D422.

(c) Oil and grease. The presence of oil and grease in both cement-based and lime/pozzolan-based systems results in the coating of waste particles and the weakening of the bonding between the particle and the stabilizing agent. This coating can inhibit bond formation, thereby decreasing the resistance of the material to leaching. Oil and grease content can be measured by EPA Method 9070.

(d) Organic compounds. The presence of organic compounds in the waste interferes with the chemical reactions. This interference inhibits setting and decreases the resistance of the material to leaching. Total organic carbon can be measured by EPA Method 9060.

(e) Sulfates and chlorides. The presence of certain inorganic compounds will interfere with the chemical reactions, weakening bond strength and prolonging setting and curing times. Sulfate and chloride compounds may reduce the diversional stability of the cured matrix, thereby increasing leaching potential. Chlorides can be measured by EPA Method 9252 and sulfates can be measured by EPA Method 9038. Accordingly, EPA will examine these constituents when making decisions regarding transfer of treatment standards based on stabilization.

(5) Design and operating parameters. In designing a stabilization system, the principal parameters that should be optimized so that the amount of leachable metal constituents is minimized are: (1) the selection of stabilizing agents and other additives, (2) the ratio of waste to stabilizing agents and other additives, (3) the degree of mixing, and (4) curing conditions.

(a) Selection of stabilizing agents and other additives. The stabilizing agent and additives used will determine the chemistry and structure of the stabilized material and thus will affect the leachability of the solid material. Stabilizing agents and additives must be carefully selected based on the chemical and physical characteristics of the waste to be stabilized. For example, the amount of sulfates in a waste should be considered when a choice is being made between a lime/pozzolan-based system and a portland cement-based system. In order to select the stabilizing agents and additives, the waste should be tested in the laboratory with a variety of materials to determine the best combination.

(b) Amount of stabilizing agents and additives. The amount of stabilizing agents and additives is a critical parameter in that sufficient stabilizing materials are necessary in the mixture to properly bind the waste constituents of concern, making them less susceptible to leaching. The appropriate weight ratios of amounts of waste to stabilizing agent and other additives are established empirically by setting up a series of laboratory tests that allow separate leachate testing of different mix ratios. The ratio of water to stabilizing agent (including water in waste) will also impact the strength and leaching characteristics of the stabilized material. Too much water will cause low strength; too little will make mixing difficult and, more important, may not allow the chemical reactions that bind the hazardous constituents to be fully completed.

(c) Mixing. This parameter includes both the type and duration of mixing. Mixing is necessary to ensure homogeneous distribution of the waste and the stabilizing agents. Both undermixing and overmixing are undesirable. The first condition results in a nonhomogeneous mixture; therefore, areas can exist within the waste where waste particles are neither chemically bonded to the stabilizing agent nor physically held within the lattice structure. Overmixing, on the other hand, may inhibit gel formation and ion adsorption in some stabilization systems. As with the relative amounts of waste, stabilizing agent, and additives within the system, optimal mixing conditions can be determined through laboratory experiments. During treatment it is important to monitor the degree (i.e., type and duration) of mixing to ensure that it reflects design conditions.

(d) Curing conditions. Curing conditions include the duration of curing and the ambient curing conditions (temperature and humidity). The duration of curing is a critical parameter to ensure that the waste particles have had sufficient time in which to form stable chemical bonds and/or lattice structures. The time necessary for complete stabilization depends upon the waste type and the stabilization used. The performance of the stabilized waste (i.e., the levels of constituents in the leachate) will be highly dependent upon whether complete stabilization has occurred. Higher temperatures and lower humidity increase the rate of curing by increasing the rate of evaporation of water from the solidification mixtures. If temperatures are too high, however, the evaporation rate can be excessive and result in too little water being available for completion of the stabilization reaction. The duration of the curing process should also be determined during the design stage and typically will be between 7 and 28 days.

3.3 Other Applicable Treatment Technologies

The Agency is aware that other existing treatment technologies may be applicable to K061 waste. Generally, these technologies have not been used on a commercial scale and therefore are not considered to be demonstrated. Based on technical publications, it is evident that recycling the waste back into the electric furnace has been attempted on a limited basis, and is a waste minimization technique that reduces the amount of waste requiring land disposal. The Agency encourages recycling and waste minimization practices. Several different strategies for direct recycle of K061 waste to steel production have been studied. Additionally, some recycle technologies use high temperature processing to prepare the material to be reintroduced to the electric furnace for reuse.

The dust may be directly injected back into the furnace or it may be pelletized or briquetted to improve handling. This step may involve the addition of water and binders to improve the strength of the pellets or briquettes. The resulting aggregate may be directly inserted into the electric furnace, or processed by high temperature roasting or sintering to improve the strength and composition of the pellets/briquettes. Recycling the waste facilitates recovery of the iron and calcium for reuse in steel making, while the volatile metals (zinc) are concentrated in the dust to the air pollution control systems.

A process related to both direct recycle of pelletized dust and high temperature metals recovery involves high temperature reduction of pelletized dust to yield metallic iron pellets for use in cupola, blast, or electric furnaces and a zinc dust for zinc smelters. This process has not been used on a full-scale basis for K061 waste. Another process that has not been demonstrated involves the recycle of K061 waste as an additive to fluxes in steel production.

Hydrometallurgical extraction techniques may be applicable to K061 waste. These techniques involve leaching metals from the dust using acidic, caustic, or special solutions, and then recovering metals from solution by precipitation and/or electrolysis. The volume of residual to be land disposed is also reduced. Hydrometallurgical technologies have limited applicability because of their lack of selectivity for leaching specific metals, however, and therefore have not been developed on a commercial scale.

4. PERFORMANCE DATA BASE

This section discusses all available performance data associated with the demonstrated technologies for K061 waste: high temperature metals recovery and stabilization. Performance data include the untreated and treated waste concentrations for a given constituent, the operating values that existed at the time the waste was being treated, the design values for the treatment technology, and data on waste characteristics that affect treatment performance. EPA has provided all such data to the extent that they are available.

EPA's use of these data in determining the technology that represents BDAT, and in the development of treatment standards, is discussed in Sections 5 and 7, respectively.

4.1 Performance Data for High Temperature Metals Recovery

The Agency has 15 data sets for treatment of K061 waste by high temperature metals recovery. Each data set consists of a paired set of analyses of untreated and treated wastes. Seven of the data sets represent data that the Agency collected on a rotary kiln unit; all other data were submitted by industry and include two data sets from plasma arc treatment, three from a rotary hearth electric furnace, two from a molten slag reactor, and one data set from treatment by a flame reactor. For high temperature metals recovery, treatment performance is measured by the reduction of metal constituents and the leachability of the metals in the residual.

Tables 4-1 to 4-16 at the end of this section summarize the treatment performance data collected for high temperature metals recovery for each of the 15 data sets. Specifically, Tables 4-1 to 4-8 present the treatment performance data for high temperature metals recovery by the rotary kiln process; Tables 4-9 and 4-10 present performance data for high temperature metals recovery by plasma arc reactor; Tables 4-11 to 4-13 present performance data from rotary hearth/electric furnace systems; Tables 4-14 and 4-15 present performance data for molten slag reactor systems; and Table 4-16 presents one performance data set for the flame reactor system. These data display the treatment provided for cadmium, chromium, lead, and zinc based on total concentration.

For all of the data and information submitted by industry on high temperature metals recovery, see the Administrative Record for K061 waste.

4.2 Performance Data for Stabilization

The stabilization data that the Agency has evaluated in the development of treatment standards for K061 waste are discussed below. EPA is presenting some of these data in this document; other data on stabilization of K061 waste, evaluated but not used in developing the treatment standards, can be found in the Administrative Record for this rulemaking.

The stabilization data that the Agency evaluated but did not use in the development of the treatment standards for F006 were generally data that contained insufficient information to assess treatment effectiveness. Specifically, the Agency either did not have the necessary data on the binder-to-waste ratios to assess dilution effects or data on the untreated leachate values were insufficient to determine whether treatment occurred. These data primarily consist of EPA delisting petition data and data submitted in response to the California List "Notice of Availability" and the First Third rule. These data consisted of both EP and TCLP data. As noted above, all these data can be found in the Administrative Record for this rulemaking.

The data that EPA is using for the development of treatment standards based on stabilization is shown in Tables 4-17 to 4-21. The data presented in Tables 4-17 to 4-20 represent performance data developed from stabilization of K061 waste, while the data in Table 4-21 represent treatment of F006 wastes. EPA is using performance data from both waste groups because the Agency does not believe that the performance data for K061 alone are sufficient to regulate two of the four Appendix VIII metals shown to have the highest total and leachable concentrations (Section 6 discusses regulated constituents). Specifically, EPA believes that the data on stabilization of K061 waste can be used to assess treatment performance for cadmium and lead; however, the Agency does not believe that these data can be used to assess the performance of stabilization for chromium and nickel. For these metals, the untreated leachate values in the K061 wastes for which data are available are already at very low concentrations (less than 0.007 mg/l for chromium and 0.027 mg/l for nickel) and therefore the treated values are not a meaningful indication of performance.

For chromium and nickel, EPA does have performance data on F006 wastes that the Agency has determined can be transferred to the K061 wastes. EPA's rationale follows. EPA compared the K061 and F006 wastes with regard to the characteristics that affect treatment performance; these characteristics include the presence of other metals and their concentrations, fine particulates, oil and grease, organic constituents, and sulfates/chlorides. Of these characteristics, EPA only had data to compare K061 and F006 wastes with regard to the presence of other metals and their concentrations, oil and grease, and organic concentrations. A review of these data with regard to metals show that with the exception of four metals, the F006 and K061 data have the same metal constituents in the waste. The four constituents present in K061 that are not present in F006 wastes are antimony, beryllium, thallium, and vanadium. These constituents, however, represent only a small part of the K061 wastes, ranging from 0.15 ppm for beryllium to 475 ppm for vanadium. Specifically, with regard to chromium and nickel, the total concentrations of these constituents in the F006 and K061 wastes are similar. Chromium is present in concentrations as high as 10 percent for K061 and 4.3 percent for F006; nickel is present in concentrations as high as 2.2 percent for K061 and 2.3 percent for F006.

EPA also compared oil and grease and total organic carbon concentrations in K061 and F006 wastes. As discussed in Section 3, these constituent parameters will also affect treatment performance. Oil and grease levels in F006 waste ranged from 30 to 37,000 mg/kg and in K061 waste were found to be 282 mg/kg. Total organic concentrations ranged from 550 to 137,000 mg/kg for F006 waste and were measured at 4,430 mg/kg in K061. Based on these data, EPA would expect that the F006 wastes would appear to be more difficult to stabilize effectively.

Based on the available data relative to waste characteristics that affect performance, the Agency has no reason to believe that the treatment levels achieved for chromium and nickel in the F006 wastes cannot also be achieved for K061. Accordingly, EPA is using F006 performance data to establish treatment standards for nickel and chromium in K061 waste.

Table 4-1 High Temperature Metals Recovery: Rotary Kiln EPA Collected Data[a]

Sample Set #1

	BDAT constituents detected		
	Untreated concentration (ppm)	Treated concentration (ppm)	Treated TCLP (mg/l)
Antimony	89	196	<0.021
Arsenic	59	77	<0.010
Barium	169	348	1.42
Beryllium	0.55	1.9	0.001
Cadmium	737	<15	<0.0042
Chromium	905	662	<0.080
Copper	2,080	3,180	<0.004
Lead	19,400	1,720	<0.025
Mercury	1.4	<0.1	<0.0002
Nickel	184	434	0.203
Selenium	13	2.5	<0.025
Silver	30	32	<0.004
Thallium	2.7	<1.0	<0.010
Vanadium	24	8.6	<0.060
Zinc	129,000	24,300	2.64

[a] Some of the design and operating data associated with these data have been claimed to be confidential. The remaining design and operating data associated with these data are shown in Table 4-8.

Reference: USEPA 1987b.

Table 4-2 High Temperature Metals Recovery: Rotary Kiln
EPA Collected Data[a]

Sample Set #2

	BDAT constituents detected		
	Untreated concentration (ppm)	Treated concentration (ppm)	Treated TCLP (mg/l)
Antimony	65	187	0.795
Arsenic	55	77	0.068
Barium	164	363	2.66
Beryllium	<0.5	1.9	0.017
Cadmium	345	<15	<0.060
Chromium	959	741	0.103
Copper	1,620	3,370	0.100
Lead	14,900	2,080	<0.025
Mercury	1.4	<0.1	<0.0002
Nickel	285	422	1.40
Selenium	18	5.7	<0.025
Silver	23	35	0.099
Thallium	1.5	<1.0	<0.010
Vanadium	26	20	<0.060
Zinc	145,000	23,600	65.7

[a] Some of the design and operating data associated with these data have been claimed to be confidential. The remaining design and operating data associated with these data are shown in Table 4-8.

Reference: USEPA 1987b.

Table 4-3 High Temperature Metals Recovery: Rotary Kiln
EPA Collected Data[a]

Sample Set #3

	BDAT constituents detected		
	Untreated concentraion (ppm)	Treated concentration (ppm)	Treated TCLP (mg/l)
Antimony	73	162	0.769
Arsenic	56	75	0.013
Barium	184	346	4.32
Beryllium	0.81	1.9	<0.001
Cadmium	394	<15	<0.060
Chromium	1,190	748	<0.080
Copper	1,980	3,290	<0.080
Lead	15,500	1,940	<0.025
Mercury	1.0	<0.1	<0.0002
Nickel	449	579	0.097
Selenium	5.2	4.2	<0.005
Silver	23	42	<0.080
Thallium	1.5	<1.0	<0.010
Vanadium	37	32	<0.060
Zinc	145,000	11,200	0.241

[a] Some of the design and operating data associated with these data have been claimed to be confidential. The remaining design and operating data associated with these data are shown in Table 4-8.

Reference: USEPA 1987b.

Table 4-4 High Temperature Metals Recovery: Rotary Kiln
EPA Collected Data[a]
Sample Set #4

	BDAT constituents detected		
	Untreated concentraion (ppm)	Treated concentration (ppm)	Treated TCLP (mg/l)
Antimony	80	405	0.853
Arsenic	65	113	<0.010
Barium	190	467	2.93
Beryllium	1.5	4.0	0.002
Cadmium	808	<15	<0.060
Chromium	903	978	<0.080
Copper	2,640	5,470	<0.004
Lead	20,800	365	<0.025
Mercury	1.6	<0.1	0.0027
Nickel	261	952	0.153
Selenium	8.2	5.2	<0.005
Silver	29	39	<0.004
Thallium	1.3	<0.5	<0.010
Vanadium	25	44	<0.060
Zinc	135,000	4,680	0.128

[a] Some of the design and operating data associated with these data have been claimed to be confidential. The remaining design and operating data associated with these data are shown in Table 4-8.

Reference: USEPA 1987b.

Table 4-5 High-Temperature Metals Recovery: Rotary Kiln
EPA Collected Data[a]

Sample Set #5

	BDAT constituents detected		
	Untreated concentraion (ppm)	Treated concentration (ppm)	Treated TCLP (mg/l)
Antimony	52	146	0.700
Arsenic	56	105	<0.010
Barium	168	383	2.64
Beryllium	0.83	3.3	0.022
Cadmium	857	<15	<0.060
Chromium	803	205	<0.080
Copper	2,610	4,560	<0.080
Lead	21,900	738	<0.025
Mercury	2.0	<0.1	<0.0002
Nickel	202	588	0.445
Selenium	4.2	3.6	<0.025
Silver	25	33	<0.080
Thallium	0.75	<1.0	<0.010
Vanadium	27	<1.5	<0.060
Zinc	145,000	6,710	26.7

[a] Some of the design and operating data associated with these data have been claimed to be confidential. The remaining design and operating data associated with these data are shown in Table 4-8.

Reference: USEPA 1987b.

Table 4-6 High Temperature Metals Recovery: Rotary Kiln
EPA Collected Data[a]

Sample Set #6

	BDAT constituents detected		
	Untreated concentraion (ppm)	Treated concentration (ppm)	Treated TCLP (mg/l)
Antimony	58	111	0.532
Arsenic	42	76	<0.010
Barium	193	331	2.35
Beryllium	<0.5	2.6	<0.001
Cadmium	298	<15	<0.060
Chromium	909	477	<0.080
Copper	1,460	3,610	<0.080
Lead	15,400	4,270	0.046
Mercury	1.1	<0.1	<0.0002
Nickel	234	460	0.579
Selenium	8.0	4.4	<0.025
Silver	37	32	<0.080
Thallium	<1.0	<1.0	<0.010
Vanadium	34	16	<0.060
Zinc	148,000	27,400	61.1

[a] Some of the design and operating data associated with these data have been claimed to be confidential. The remaining design and operating data associated with these data are shown in Table 4-8.

Reference: USEPA 1987b.

Table 4-7 High Temperature Metals Recovery: Rotary Kiln EPA Collected Data[a]

Sample Set #7

	BDAT constituents detected		
	Untreated concentraion (ppm)	Treated concentration (ppm)	Treated TCLP (mg/l)
Antimony	78	155	0.344
Arsenic	127	79	<0.010
Barium	204	381	3.690
Beryllium	<0.5	1.7	<0.001
Cadmium	290	<15	<0.060
Chromium	1,080	476	<0.080
Copper	1,590	3,190	<0.040
Lead	16,400	2,370	<0.025
Mercury	1.1	<0.1	<0.0002
Nickel	295	683	0.024
Selenium	20	8.8	<0.005
Silver	44	59	<0.040
Thallium	<1.0	<1.0	<0.010
Vanadium	33	31	<0.030
Zinc	155,000	4,550	0.080

[a] Some of the design and operating data associated with these data have been claimed to be confidential. The remaining design and operating data associated with these data are shown in Table 4-8.

Reference: USEPA 1987b.

Table 4-8 High Temperature Metals Recovery: Rotary Kiln - Design and Operating Data and Waste Characteristics Affecting Performance EPA Collected Data

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Waste Characteristics Affecting Performance[a]

Boiling Point (in increasing order) -

Mercury	356°C
Cadmium	765°C
Zinc	907°C
Lead	1760°C
Chromium	2672°C

Type of Metal - No low boiling point metals are present in concentrations that could impact product purity and use.

Thermal Conductivity[b] - The thermal conductivity of K061 waste has been estimated to be approximately 28 Btu/hr-ft°F.

Design and Operating Data for Rotary Kiln High Temperature Metals Recovery

Parameter	Nominal value[c]	Operating value						
		6/2/87			6/3/87			
		SS #1	SS #2	SS #3	SS #4	SS #5	SS #6	SS #7
Kiln Temperature (°C)[d]	700-800	760-840[e]	730-820[e]	740-840[e]	720-840[f]	600-1065[f]	575-740[f]	575-740[f]
Feed Rate (ton/hr)		-	-	-	-	-	-	-
Rate of Rotation (min/rev)		1.5	1.5	1.3	1.5	1.1	1.1	1.1
Zinc Content (%)		-	-	-	-	-	-	-
Moisture Content (%)		13.3	10.8	11.2	14.7	11.4	14.4	9.2
Carbon Content (%)		-	-	-	-	-	-	-
Calcium/Silica Ratio		3.48	3.33	9.84	5.6	5.89	8.54	8.8

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[a] The waste characteristics affecting performance for high temperature metals recovery are relative volatility and the heat transfer characteristics of the waste. As the best approximate measure of the parameters, EPA is using boiling point and thermal conductivity.

[b] Thermal conductivity was calculated based on major constituents present in the waste and their respective thermal conductivities. This calculation can be found in the Administrative Record for K061.

[c] This system was built in the 1920s and was not originally designed for treatment of K061 waste. Nominal values were developed by the plant in lieu of design values.

[d] A temperature strip chart is included in Appendix C.

[e] Values reflect those for kiln #2. .

[f] Values reflect those for kiln #3.

Reference: USEPA 1987b.

Table 4-9 High Temperature Metals Recovery: Plasma Arc Reactor
Sample Set #1
(Stainless Steel)

	BDAT constituents detected		
	Untreated waste (ppm)	Treated waste (slag) (ppm)	Treated water (mg/l)
Antimony	-	20	0.100
Arsenic	-	2.1	<0.04
Barium	-	<200	<0.250
Beryllium	-	-	0.0014
Cadmium	100-600	<2	<0.002-0.004
Chromium	60,000-100,000	40,000-170,000	0.05-0.10
Copper	600-3,000	10	0.10-0.14
Lead	6,000-14,000	<5	<0.01
Mercury	0.7-16	<1	0.0001-0.0011
Nickel	15,000-22,000	300-2,200	<0.01-0.02
Selenium	-	-	0.450
Silver	-	-	-
Thallium	-	-	-
Vanadium	-	-	-
Zinc	22,000-53,000	50-98	0.05-0.10

- = No data.

Comments:

1. For the untreated waste, EPA has values for ranges only. Data were not available on the specific untreated values that corresponded to the treated values.

2. Data were not provided showing the specific operating conditions at the time the wastes were treated.

3. No data were provided on treatment characteristics that affect performance.

Reference: SKF Plasmadust Data.

Table 4-10 High Temperature Metals Recovery: Plasma Arc Reactor
Sample Set #2
(Carbon Steel)

	BDAT constituents detected				
	Untreated waste (ppm)	Treated waste (slag) (ppm)	Treated waste (slag) TCLP (ppm)	Treated sludge (ppm)	Treated water (mg/l)
Antimony	50-150	<20	-	<20	0.020-0.100
Arsenic	<100-400	<4-13	<0.005	1.6	<0.040
Barium	-	<3,000	2.5	<200	0.02-0.140
Beryllium	-	-	-	-	0.00016-0.00021
Cadmium	200-900	<10-500	<0.005	550	0.005-0.018
Chromium	400-5,000	2,000-12,000	0.013	23	0.03-0.08
Copper	1,500-2,800	10-1,500	-	-	0.05-0.30
Lead	24,000-50,000	50-1,500	<0.05	900	<0.01-0.01
Mercury	7-41	<5	<0.0002	0.59	0.0013-0.006
Nickel	1,000-3,000	200-1,000	0.22	-	<0.01-0.03
Selenium	-	-	<0.05	-	<0.040
Silver	-	-	0.014	-	-
Thallium	-	-	-	-	-
Vanadium	-	-	<0.02	<1,000	-
Zinc	150,000-320,000	50-2,000	-	3,500	0.05-0.08

- = No data.

Comments:

1. For the untreated waste, EPA has values for ranges only. Data were not available on the specific untreated values that corresponded to the treated values.

2. Data were not provided showing the specific operating conditions at the time the wastes were treated.

3. No data were provided on treatment characteristics that affect performance.

Reference: SKF Plasmadust Data.

Table 4-11 High Temperature Metals Recovery: Rotary Hearth/Electric Furnace

Sample Set #1

Constituent	Untreated waste TCLP (ppm)	Treated waste TCLP (ppm)
Chromium(+6)	213	0.62
Chromium	256	0.65

Comments:

1. Data were not provided on untreated total concentrations.

2. Data were not provided on the design and operating values.

3. Data were not provided on waste characteristics that affect performance.

Reference: INMETCO Data for Rotary Hearth/Electric Furnace.

Table 4-12 High Temperature Metals Recovery: Rotary Hearth/Electric Furnace

Sample Set #2

Constituent	Untreated waste TCLP (ppm)	Treated waste TCLP (ppm)
Lead	0.39	0.35
Chromium	6.8	0.40
Chromium(+6)	5.4	0.28

Comments:

1. Data were not provided on untreated total concentrations.
2. Data were not provided on the design and operating values.
3. Data were not provided on waste characteristics that affect performance.

Reference: INMETCO Data for Rotary Hearth/Electric Furnace.

Table 4-13 High Temperature Metals Recovery: Rotary Hearth/Electric Furnace

Sample Set #3

Constituent	Untreated waste TCLP (ppm)	Treated waste TCLP (ppm)
Lead	365	0.38
Zinc	4973	0.94
Cadmium	56	0.05
Chromium	<0.1	<0.10

Comments:

1. Data were not provided on untreated total concentrations.

2. Data were not provided on the design and operating values.

3. Data were not provided on waste characteristics that affect performance.

Reference: INMETCO Data for Rotary Hearth/Electric Furnace.

Table 4-14 High Temperature Metals Recovery: Molten Slag System

Sample Set #1

	BDAT constituents detected	
	Untreated waste (ppm)	Treated slag (ppm)
Antimony	-	-
Arsenic	trace	trace
Barium	-	-
Beryllium	-	-
Cadmium	600	trace
Chromium	3,900	6,500
Copper	-	-
Lead	4,500	200
Mercury	-	-
Nickel	-	-
Selenium	-	-
Silver	-	-
Thallium	-	-
Vanadium	-	-
Zinc	188,200	12,200

- = No data.

Comments:

1. Data were not provided on untreated total concentrations.
2. Data were not provided on the design and operating values.
3. Data were not provided on waste characteristics that affect performance.

Reference: Sumitomo Molten Slag Data.

Table 4-15 High Temperature Metals Recovery: Molten Slag System

Sample Set #2

	BDAT constituents detected	
	Untreated waste EP Tox (ppm)	Treated slag EP Tox (ppm)
Antimony	-	-
Arsenic	-	-
Barium	-	-
Beryllium	-	-
Cadmium	20.2-30.0	0.01-0.07
Chromium	0.7-1.4	0.04-0.3
Copper	-	-
Lead	348-556	0.05-0.80
Mercury	-	-
Nickel	-	-
Selenium	-	-
Silver	-	-
Thallium	-	-
Vanadium	-	-
Zinc	-	-

- = No data.

Comments:

1. Data were not provided on untreated total concentrations.

2. Data were not provided on the design and operating values.

3. Data were not provided on waste characteristics that affect performance.

Reference: Sumitomo Molten Slag Data.

Table 4-16 High Temperature Metals Recovery: Flame Reactor

	BDAT constituents detected	
	Untreated waste (ppm)	Treated waste (ppm)
Antimony	-	-
Arsenic	-	-
Barium	-	-
Beryllium	-	-
Cadmium	1,000	50
Chromium	8,000	13,000
Copper	-	-
Lead	30,000	2,000
Mercury	-	-
Nickel	-	-
Selenium	-	-
Silver	-	-
Thallium	-	-
Vanadium	-	-
Zinc	220,000	40,000

- = No Data

Comments:

1. Data were not provided on untreated total concentrations.

2. Data were not provided on the design and operating values.

3. Data were not provided on waste characteristics that affect performance.

Reference: St. Joe Flame Reactor Data.

Table 4-17 Stabilization Testing[a] - EPA Collected Data

Test #1 - Binder: Cement

	Untreated waste		Treated waste - TCLP (mg/l)		
BDAT constituents	Total (ppm)	TCLP (mg/l)	Run #1	Run #2	Run #3
Antimony	294	0.040	<0.050	<0.050	<0.050
Arsenic	36	<0.010	<0.010	<0.010	<0.010
Barium	238	0.733	0.670	0.550	0.516
Beryllium	0.15	<0.001	<0.001	<0.001	<0.001
Cadmium	481	12.8	2.86	3.64	3.38
Chromium	1,370	<0.007	0.049	0.039	0.040
Copper	2,240	0.066	0.058	0.009	0.005
Lead	20,300	45.1	1.03	1.20	1.24
Mercury	3.8	0.0026	0.0013	0.0014	0.0012
Nickel	243	0.027	0.024	0.014	0.018
Selenium	<5.0	<0.050	<0.010	<0.010	<0.010
Silver	59	0.021	<0.003	<0.003	<0.003
Thallium	<1.0	0.038	<0.007	0.013	0.015
Vanadium	25	<0.006	0.084	0.091	0.290
Zinc	244,000	445	21.0	23.5	23.4

[a] Design and operating data associated with these data can be found in Table 4-20.

Reference: USEPA 1988.

Table 4-18 Stabilization Testing[a] - EPA Collected Data

Test #2 - Binder: Kiln Dust

BDAT constituents	Untreated waste Total (ppm)	Untreated waste TCLP (mg/l)	Treated waste - TCLP (mg/l) Run #4	Treated waste - TCLP (mg/l) Run #5	Treated waste - TCLP (mg/l) Run #6
Antimony	294	0.040	<0.050	<0.050	<0.050
Arsenic	36	<0.010	<0.010	<0.010	<0.010
Barium	238	0.733	0.516	0.454	0.552
Beryllium	0.15	<0.001	<0.001	<0.001	<0.001
Cadmium	481	12.8	2.92	1.80	0.508
Chromium	1,370	<0.007	0.027	0.035	0.034
Copper	2,240	0.066	0.019	<0.004	0.016
Lead	20,300	45.1	1.30	0.711	0.350
Mercury	3.8	0.0026	0.0005	0.0008	0.0009
Nickel	243	0.027	<0.012	<0.012	<0.012
Selenium	<5.0	<0.05	<0.010	<0.010	<0.010
Silver	59	0.021	<0.003	<0.003	<0.003
Thallium	<1.0	0.038	0.012	0.011	0.010
Vanadium	25	<0.006	0.083	0.088	0.091
Zinc	244,000	445	14.2	6.12	2.00

[a] Design and operating data associated with these data can be found in Table 4-20.

Reference: USEPA 1988.

Table 4-19 Stabilization Testing[a] - EPA Collected Data

Test #3 - Binder: Lime/Fly Ash

	Untreated waste		Treated waste - TCLP (mg/l)		
BDAT constituents	Total (ppm)	TCLP (mg/l)	Run #7	Run #8	Run #9
Antimony	294	0.040	<0.050	<0.050	<0.050
Arsenic	36	<0.010	<0.010	<0.010	<0.010
Barium	238	0.733	0.462	0.431	0.500
Beryllium	0.15	<0.001	<0.001	<0.001	<0.001
Cadmium	481	12.8	0.033	0.049	0.073
Chromium	1,370	<0.007	0.093	0.072	0.053
Copper	2,240	0.066	0.015	<0.004	0.008
Lead	20,300	45.1	0.150	0.069	0.066
Mercury	3.8	0.0026	0.0016	0.0017	0.0018
Nickel	243	0.027	<0.012	<0.012	<0.012
Selenium	<5.0	<0.05	<0.025	<0.025	<0.010
Silver	59	0.021	<0.003	<0.003	<0.003
Thallium	<1.0	0.038	0.012	0.014	0.011
Vanadium	25	<0.006	0.080	0.089	0.085
Zinc	244,000	445	0.592	0.179	0.398

[a] Design and operating data associated with these data can be found in Table 4-20.

Reference: USEPA 1988.

Table 4-20 Stabilization Testing - Design and Operating Data and Waste Characteristics Affecting Performance

	Design and operating data								
	Stabilization process/binder								
	Cement			Kiln dust			Lime and fly ash[a]		
Parameter	Run #1	Run #2	Run #3	Run #4	Run #5	Run #6	Run #7	Run #8	Run #9
Binder-to-Waste Ratio	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.10	0.10
Water-to-Waste Ratio	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Mixture pH	10.9	11.5	10.5	11.5	11.6	11.1	12.1	12.0	12.0
Cure Time (Days)	28	28	28	28	28	28	28	28	28
Unconfined Compressive Strength (lb/in^2)	59.7	88.8	95.7	133.0	167.2	141.2	54.6	58.0	50.7

Waste Characteristics Affecting Performance

Fine Particulates - 90% of the waste composed of particles <63 um or less than 230 mesh sieve size

Oil and Grease - 282 ppm

Sulfates - 8,440 ppm

Chlorides - 19,300 ppm

Total Organic Carbon - 4,430 ppm

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[a] Each binder consisted of equal parts of lime and fly ash.

Reference: USEPA 1988.

Table 4-21 Performance Data for Untreated and Treated F006 Wastes

Source	Oil and grease (mg/kg)	TOC (mg/kg)	Mix ratio[a]	Metal concentrations (ppm) Arsenic	Barium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Unknown														
Unstabilized														
As received	1,520	14,600		-	36.4	1.3	1270	40.2	35.5	-	435	-	2.3	1560
TCLP				<0.01	0.08	0.01	0.34	0.15	0.26	<0.001	0.71	<0.01	0.01	0.16
Stabilized														
TCLP			0.2	<0.01	0.12	0.01	0.51	0.20	0.30	<0.001	0.04	0.06	0.03	0.03
Autopart manufacturing														
Unstabilized														
As received	60	1,500		-	21.6	31.3	755	7030	409	-	989	-	6.62	4020
TCLP				<0.01	0.32	2.21	0.76	368	10.7	<0.001	22.7	<0.01	0.14	219
Stabilized														
TCLP			0.2	<0.01	0.50	0.50	0.40	5.4	0.40	<0.001	1.5	0.06	0.03	36.9
TCLP			0.5	<0.01	0.42	0.01	0.39	0.25	0.36	<0.001	0.03	0.11	0.05	0.01
Aircraft overhauling facility														
Unstabilized														
As received	37,000	137,000		-	85.5	67.3	716	693	25.7	-	259	-	39	631
TCLP				0.01	1.41	1.13	0.43	1.33	0.26	<0.001	1.1	<0.01	0.02	5.41
Stabilized														
TCLP			0.2	<0.01	0.33	0.06	0.08	1.64	0.30	<0.001	0.23	0.07	0.20	0.05
TCLP			0.5	<0.01	0.31	0.02	0.20	1.84	0.41	<0.001	0.15	0.11	0.05	0.03
Aerospace manufacturing (mixture of F006 & F007)														
Unstabilized														
As received	3,870	8,280		-	0.74	1.69	12.9	18.6	11.4	-	234	-	6.26	8.86
TCLP				<0.01	0.83	0.66	7.58	4.12	6.86	0.003	158	<0.01	1.64	2.28
Stabilized														
TCLP			1.0	<0.01	0.52	<0.01	0.40	0.23	0.20	<0.001	4.35	0.17	0.09	0.05
TCLP			1.5	<0.01	1.18	0.01	0.34	0.19	0.36	<0.001	2.47	0.20	0.15	0.03

Table 4-21 (Continued)

Source	Oil and grease (mg/kg)	TOC (mg/kg)	Mix ratio[a]	Metal concentrations (ppm)										
				Arsenic	Barium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Zinc plating														
Unstabilized														
As received	1,150	21,200		-	17.2	1.30	110	1510	88.5		37	-	9.05	90200
TCLP				-	0.84	0.22	0.18	4.6	0.45	<0.001	0.52	-	0.16	2030
Stabilized														
TCLP			0.2	<0.01	0.20	0.01	0.23	0.30	0.30	<0.001	0.10	0.08	0.03	32
TCLP			0.5	<0.01	0.23	0.01	0.30	0.27	0.34	<0.001	0.02	0.14	0.04	0.04
Unknown														
Unstabilized														
As received	20,300	28,600		-	14.3	720	12200	160	52	-	701	-	5.28	35900
TCLP				<0.01	0.38	23.6	25.3	1.14	0.45	<0.001	9.78	<0.01	0.08	867
Stabilized														
TCLP			0.2	<0.01	0.31	3.23	0.25	0.20	0.24	<0.001	0.53	0.04	0.04	3.4
TCLP			0.5	<0.01	0.19	0.01	0.38	0.29	0.36	<0.001	0.04	0.09	0.06	0.03
Small engine manufacturing														
Unstabilized														
As received	2,770	6,550		-	24.5	7.28	3100	1220	113	-	19400	-	4.08	27800
TCLP				<0.01	0.07	0.3	38.7	31.7	3.37	0.003	730	<0.01	0.12	1200
Stabilized														
TCLP			0.2	<0.01	0.30	0.02	0.21	0.21	0.30	<0.001	16.5	0.05	0.03	36.3
TCLP			0.5	<0.01	0.33	0.01	0.76	0.20	0.36	<0.001	0.05	0.11	0.05	0.04
Circuit board manufacturing[b]														
Unstabilized														
As received	130	550		-	12.6	5.39	42900	10600	156	-	13000	-	12.5	120
TCLP				<0.01	0.04	0.06	360	8.69	1.0	<0.001	152	<0.01	0.05	0.62
Stabilized														
TCLP			0.2	<0.01	0.04	0.01	3.0	0.40	0.30	<0.001	0.40	0.04	0.03	0.02
TCLP			0.5	<0.01	0.14	0.01	1.21	0.42	0.38	<0.001	0.10	0.07	0.05	0.02

Table 4-21 (Continued)

Source	Oil and grease (mg/kg)	TOC (mg/kg)	Mix ratio[a]	Metal concentrations (ppm)										
				Arsenic	Barium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Unknown														
Unstabilized														
As received	30	10,700		-	15.3	5.81	47.9	17600	169	-	23700	-	8.11	15700
TCLP				<0.01	0.53	0.18	0.04	483	4.22	<0.001	644	<0.01	0.31	650
Stabilized														
TCLP			0.2	<0.01	0.32	0.01	0.10	0.50	0.31	<0.001	15.7	0.07	0.03	4.54
TCLP			0.5	<0.01	0.27	0.01	0.2	0.32	0.37	<0.001	0.04	0.07	0.05	0.02
Unknown														
Unstabilized														
As received	1,430	5,960		-	19.2	5.04	644	27400	24500	-	5730	-	19.1	322
TCLP				0.88	0.28	0.01	0.01	16.9	50.2	<0.001	16.1	<0.45	<0.01	1.29
Stabilized														
TCLP			0.2	<0.02	0.19	<0.01	0.03	3.18	2.39	<0.001	1.09	<0.01	<0.01	0.07
TCLP			0.5	<0.02	0.08	<0.01	0.21	0.46	0.27	<0.001	0.02	<0.01	<0.01	<0.01

[a] Mix ratio = $\frac{\text{weight of reagent}}{\text{weight of waste}}$

[b] Circuit board manufacturing waste is not in its entirety defined as F006; however, an integral part of the manufacturing operation is electroplating. Treatment residuals generated from treatment of these electroplating wastes are F006.

Reference: CWM 1987.

5. IDENTIFICATION OF BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)

In this section, EPA explains its determination of which technology represents BDAT for each of the two K061 subcategories. As discussed in detail in Section 1, this determination essentially involves determining which of the "demonstrated" technologies will provide the "best" treatment and, at the same time, be determined to be "available" (i.e., the technology is commercially available and provides substantial treatment).

5.1 High Zinc Subcategory (greater than or equal to 15 percent zinc)

As explained in Section 3, EPA has determined that the "demonstrated" technologies for the high zinc subcategory are high temperature metals recovery (HTMR) and stabilization. Of these technologies, EPA has determined that high temperature metals recovery provides the "best" level of treatment.

EPA compared the performance achieved by HTMR with that of stabilization for the BDAT metals listed in Appendix VIII. HTMR achieves significant reductions in total concentration for cadmium and lead; therefore, it is clearly better than stabilization with regard to this measure of performance because stabilization is not intended to reduce the total metal concentration.

With regard to performance measured by the TCLP leachate values, EPA compared these technologies using a statistical test known as the Analysis of Variance Test (ANOVA).

In general, EPA screens all the performance data to ensure that none of the data represent poor design and poor operation and that the data were adjusted for analytical accuracy. This screening step is necessary to make sure that performance data are compared on an equivalent basis. For these technologies, EPA analytically adjusted data for HTMR and stabilization, but only evaluated design and operating data for stabilization. EPA did not believe it appropriate to screen HTMR data relative to design and operation because under a soon to be promulgated rule the treated residual from HTMR will undoubtedly not be classified as a "K061 derived-from" waste. As a result, the treated slag will represent routine recovery operating conditions and not necessarily the optimum operating conditions for treatment of K061 waste. Accordingly, EPA made its statistical comparison using all performance data from HTMR.

The analysis of variance test showed that for cadmium and chromium, the technologies perform similarly with regard to leachate concentrations (see Table 5-1 at the end of this section and Appendix D). For lead, HTMR performs better than stabilization, where, for nickel, stabilization performs better. Although results from HTMR and stabilization are similar with regard to leachate concentrations, HTMR significantly reduces the total concentrations of cadmium and lead. Based on these results, EPA believes that HTMR represents the "best" level of performance for the high zinc subcategory of K061 waste.

In addition to being "best," EPA finds that HTMR for the high zinc subcategory meets the criteria of "available," since HTMR is commercially available and provides substantial treatment. EPA's determination of substantial is presented below.

For the reasons discussed above, EPA is using all the performance data from HTMR in its determination of substantial. These data show that HTMR reduces total concentrations of cadmium by as much as 842 mg/kg and total concentrations of lead by as much as 21,162 mg/kg. Additionally, TCLP leachate values for the same constituents are reduced from 12.8 to 0.004 mg/l for cadmium and from 45.1 to less than 0.025 mg/l for lead. The Agency believes that these reductions represent substantial treatment.

The demonstrated technology of HTMR has been shown to be "best" and "available"; therefore, this technology represents BDAT for the high zinc subcategory of K061.

5.2 Low Zinc Subcategory (less than 15 percent zinc)

As discussed in Section 3, EPA has determined that stabilization is the only technology "demonstrated" for the K061 low zinc subcategory. Therefore, this technology provides the "best" level of performance for the K061 low zinc subcategory. In addition to being best, EPA finds that stabilization meets the Agency's promulgated criteria for available. It is commercially available and provides substantial treatment. EPA's determination of substantial is discussed below.

Stabilization reduces the TCLP leachate values from 12.8 to 0.036 mg/l for cadmium and from 45.1 to 0.061 mg/l for lead. For chromium and nickel, EPA believes that leachate values for certain K061 wastes will be reduced from 360 to 1.41 mg/l and from 730 to 0.055 mg/l, respectively. The analysis for chromium and nickel is based on a review of the data for F006 waste (see Table 5-2). The Agency believes that these reductions represent substantial treatment.

The demonstrated technology of stabilization has been shown to be "best and "available"; therefore, this technology represents BDAT for the low zinc subcategory of K061 waste.

Table 5-1 Data for ANOVA Between High Temperature Metals Recovery and Stabilization
(Accuracy-Corrected Values)

	Cadmium (mg/l) TCLP		Chromium (mg/l) TCLP		Lead (mg/l) TCLP		Nickel (mg/l) TCLP	
SS#	HTMR	Stabilization (lime/fly ash)	HTMR	Stabilization (lime/fly ash)	HTMR	Stabilization (lime/fly ash)	HTMR	Stabilization (lime/fly ash)
1	0.048	0.036	<0.006	0.113	<0.033	0.140	0.233	0.014
2	0.069	0.053	0.151	0.087	<0.033	0.064	1.61	0.014
3	0.069	0.080	<0.118	0.065	<0.007	0.061	0.112	0.014
4	0.003		<0.118		<0.007		0.176	
5	0.069		<0.118		<0.007		0.512	
6	0.003		<0.118		<0.0607		0.066	
7	0.003		<0.059		<0.053		0.028	

References: USEPA 1987 and USEPA 1988.

Table 5-2 Accuracy-Corrected Performance Data for Untreated and Treated F006 Wastes by Stabilization

Source	Mix ratio[a]	Metal concentrations (ppm)							
		Barium	Cadmium	Chromium	Copper	Lead	Nickel	Silver	Zinc
Unknown									
Unstabilized									
As received		-	-	-	-	-	435	-	1560
TCLP		-	-	-	-	-	0.71	-	0.16
Stabilized									
TCLP	0.2	-	-	-	-	-	0.05	-	0.03
Autopart manufacturing									
Unstabilized									
As received		-	31.3	755	7030	409	989	6.62	4020
TCLP		-	2.21	0.76	638	10.7	22.7	0.14	219
Stabilized									
TCLP	0.5	-	0.01	0.45	0.27	0.39	0.03	0.06	0.01
Aircraft overhauling									
Unstabilized									
As received		85.5	67.3	716	-	-	259	-	631
TCLP		1.41	1.13	0.43	-	-	1.1	-	5.41
Stabilized									
TCLP	0.2	0.34	0.06	0.09	-	-	0.27	-	0.03
Zinc plating									
Unstabilized									
As received		17.2	1.30	-	1510	-	37	9.05	90,200
TCLP		0.84	0.22	-	4.6	-	0.52	0.16	2050
Stabilized									
TCLP	0.5	0.25	0.01	-	0.21	-	0.02	0.05	0.04
Unknown									
Unstabilized									
As received		14.3	720	12,200	160	-	701	-	25,900
TCLP		0.38	23.6	25.3	1.14	-	9.78	-	867
Stabilized									
TCLP	0.5	0.21	0.01	0.44	0.31	-	0.04	-	0.03

Table 5-2 (Continued)

Source	Mix ratio[a]	Metal concentrations (ppm)							
		Barium	Cadmium	Chromium	Copper	Lead	Nickel	Silver	Zinc
Small engine manufacturing									
Unstabilized									
As received		-	7.28	3,100	1220	113	19,400	4.08	27,800
TCLP		-	0.3	38.7	31.7	3.37	730	0.12	1200
Stabilized									
TCLP	0.5	-	0.01	0.89	0.31	0.39	0.06	0.06	0.040
Circuit board manufacturing									
Unstabilized									
As received		-	5.39	42,900	10,600	156	13,000	-	120
TCLP		-	0.06	360	8.69	1.0	152	-	0.62
Stabilized									
TCLP	0.5	-	0.01	1.41	0.45	0.41	0.11	-	0.020
Unknown									
Unstabilized									
As received		15.3	5.81	-	17,600	169	23,700	8.11	15,700
TCLP		0.53	0.18	-	483	4.22	644	0.31	650
Stabilized									
TCLP	0.5	0.294	0.01	-	0.35	0.40	0.04	0.06	0.020
Unknown									
Unstabilized									
As received		19.2	-	-	27,400	24,500	5,730	-	322
TCLP	-	0.28	-	-	16.9	50.2	16.1	-	1.29
Stabilized									
TCLP	0.5	0.087	-	-	0.50	0.29	<0.02	-	<0.01

[a] Mix ratio = $\frac{\text{weight of reagent}}{\text{weight of waste}}$

Reference: CWM 1987.

6. SELECTION OF REGULATED CONSTITUENTS

As discussed in Section 1, the Agency has developed a list of hazardous constituents (see Table 1-1) from which the constituents to be regulated are selected. EPA may revise this list as additional data and information become available. The list is divided into the following categories: volatile organics, semivolatile organics, metals, inorganics other than metals, organochlorine pesticides, phenoxyacetic acid herbicides, organophosphorous insecticides, PCBs, and dioxins and furans.

This section describes the selection of the constituents to be regulated for K061 waste. In general, EPA regulates all constituents that are found in the untreated waste at treatable concentrations and are unlikely to be reduced by regulation of other constituents. As noted in the Executive Summary, EPA is only regulating specific constituents for K061 waste where the treatment technology represents stabilization.

6.1 Identification of BDAT List Constituents in K061 Waste

As discussed in Sections 2 and 4, the Agency has characterization data as well as performance data from treatment of K061 waste. All these data, along with information on the waste generating process, have been used to determine which BDAT list constituents may be present in the waste and thus which are potential candidates for regulation in K061 nonwastewater.

Table 6-1 at the end of this section shows which constituents were analyzed, which constituents were detected, and which constituents the Agency believes to be present even though not detected in the untreated waste. For constituents that were detected, the concentration range is shown.

Under the column "Believed to be present," constituents other than those detected in the untreated waste are marked with X or Y if EPA believes they are likely to be present in the untreated waste. For those constituents marked with X, an engineering analysis of the waste generating process indicates that they are likely to be present (e.g., the engineering analysis shows that a particular constituent is a major raw material). Those constituents marked with Y have been detected in the treated residual(s) and thus EPA believes that they are present in the untreated waste. Constituents may not have been detected in the untreated waste for one of several reasons: (1) none of the untreated waste samples were analyzed for these constituents, (2) masking or interference by other constituents prevented detection, and/or (3) the constituent is indeed not present (such a case may occur when the waste of concern is defined as being generated by a process and the process may involve a number of different constituents, only some of which would be present in any given sample).

6.2 Selection of Constituents

As shown in Table 6-1, 24 constituents have been detected and no additional constituents have been identified as believed to be present. Of these constituents, EPA has selected cadmium, chromium, lead, and nickel for regulation. Of the remaining constituents that are not being regulated, five are believed to be treatable. EPA is not regulating copper and zinc because they are not in Appendix VIII as elemental constituents, but rather are listed in Appendix VIII as specific metal compounds (i.e., copper cyanide, zinc phosphate, and zinc cyanide).

Regulation of the other BDAT metals will reduce leachate concentrations of both these metals. EPA is not regulating any of the other treatable constituents because the untreated leachate concentrations of these metals are far below the regulated constituents. The highest leachate concentration of the constituents not regulated is 13.5 mg/l for barium; in comparison, cadmium leachate concentration is as high as 630 mg/l, chromium as high as 216 mg/l, lead as high as 95 mg/l, and nickel as high as 730 mg/l. The untreated leachate values are shown in Table 2-7; the untreated nickel leachate value was obtained from F006 waste that had similar total concentrations of nickel.

Table 6-1 Status of BDAT List Constituent Presence in Untreated K061 Waste

BDAT reference no.	Constituent	Detection status (mg/kg)	Believed to be present
	Volatile organics		
222.	Acetone	0.49	
1.	Acetonitrile	ND	
2.	Acrolein	ND	
3.	Acrylonitrile	ND	
4.	Benzene	ND	
5.	Bromodichloromethane	ND	
6.	Bromomethane	ND	
223.	n-Butyl alcohol	NA	
7.	Carbon tetrachloride	ND	
8.	Carbon disulfide	ND	
9.	Chlorobenzene	ND	
10.	2-Chloro-1,3-butadiene	ND	
11.	Chlorodibromomethane	ND	
12.	Chloroethane	ND	
13.	2-Chloroethyl vinyl ether	ND	
14.	Chloroform	ND	
15.	Chloromethane	ND	
16.	3-Chloropropene	ND	
17.	1,2-Dibromo-3-chloropropane	ND	
18.	1,2-Dibromoethane	ND	
19.	Dibromomethane	ND	
20.	trans-1,4-Dichloro-2-butene	ND	
21.	Dichlorodifluoromethane	ND	
22.	1,1-Dichloroethane	ND	
23.	1,2-Dichloroethane	ND	
24.	1,1-Dichloroethylene	ND	
25.	trans-1,2-Dichloroethene	ND	
26.	1,2-Dichloropropane	ND	
27.	trans-1,3-Dichloropropene	ND	
28.	cis-1,3-Dichloropropene	ND	
29.	1,4-Dioxane	ND	
224.	2-Ethoxyethanol	NA	
225.	Ethyl acetate	NA	
226.	Ethyl benzene	NA	
30.	Ethyl cyanide	ND	
227.	Ethyl ether	NA	
31.	Ethyl methacrylate	ND	
214.	Ethylene oxide	NA	
32.	Iodomethane	ND	
33.	Isobutyl alcohol	ND	
228.	Methanol	NA	
34.	Methyl ethyl ketone	ND	

Table 6-1 (Continued)

BDAT reference no.	Constituent	Detection status (mg/kg)	Believed to be present
	Volatile organics (continued)		
229.	Methyl isobutyl ketone	NA	
35.	Methyl methacrylate	NA	
37.	Methacrylonitrile	ND	
38.	Methylene chloride	ND	
230.	2-Nitropropane	NA	
39.	Pyridine	NA	
40.	1,1,1,2-Tetrachloroethane	NA	
41.	1,1,2,2-Tetrachloroethane	NA	
42.	Tetrachloroethene	0.007	
43.	Toluene	ND	
44.	Tribromomethane	ND	
45.	1,1,1-Trichloroethane	ND	
46.	1,1,2-Trichloroethane	ND	
47.	Trichloroethene	ND	
48.	Trichloromonofluoromethane	ND	
49.	1,2,3-Trichloropropane	ND	
231.	1,1,2-Trichloro-1,2,2-trifluoroethane	NA	
50.	Vinyl chloride	ND	
215.	1,2-Xylene	NA	
216.	1,3-Xylene	NA	
217.	1,4-Xylene	NA	
	Semivolatile organics		
51.	Acenaphthalene	ND	
52.	Acenaphthene	ND	
53.	Acetophenone	ND	
54.	2-Acetylaminofluorene	ND	
55.	4-Aminobiphenyl	ND	
56.	Aniline	ND	
57.	Anthracene	ND	
58.	Aramite	ND	
59.	Benz(a)anthracene	NA	
218.	Benzal chloride	ND	
60.	Benzenethiol	ND	
61.	Deleted		
62.	Benzo(a)pyrene	ND	
63.	Benzo(b)fluoranthene	0.57	
64.	Benzo(ghi)perylene	ND	
65.	Benzo(k)fluoranthene	ND	
66.	p-Benzoquinone	ND	

Table 6-1 (Continued)

BDAT reference no.	Constituent	Detection status (mg/kg)	Believed to be present
	Semivolatile organics (continued)		
67.	Bis(2-chloroethoxy)methane	ND	
68.	Bis(2-chloroethyl)ether	ND	
69.	Bis(2-chloroisopropyl)ether	ND	
70.	Bis(2-ethylhexyl)phthalate	1.4	
71.	4-Bromophenyl phenyl ether	ND	
72.	Butyl benzyl phthalate	ND	
73.	2-sec-Butyl-4,6-dinitrophenol	ND	
74.	p-Chloroaniline	ND	
75.	Chlorobenzilate	ND	
76.	p-Chloro-m-cresol	ND	
77.	2-Chloronaphthalene	ND	
78.	2-Chlorophenol	ND	
79.	3-Chloropropionitrile	ND	
80.	Chrysene	0.61	
81.	ortho-Cresol	ND	
82.	para-Cresol	ND	
232.	Cyclohexanone	NA	
83.	Dibenz(a,h)anthracene	ND	
84.	Dibenzo(a,e)pyrene	ND	
85.	Dibenzo(a,i)pyrene	ND	
86.	m-Dichlorobenzene	ND	
87.	o-Dichlorobenzene	ND	
88.	p-Dichlorobenzene	ND	
89.	3,3'-Dichlorobenzidine	ND	
90.	2,4-Dichlorophenol	ND	
91.	2,6-Dichlorophenol	ND	
92.	Diethyl phthalate	ND	
93.	3,3'-Dimethoxybenzidine	ND	
94.	p-Dimethylaminoazobenzene	ND	
95.	3,3'-Dimethylbenzidine	ND	
96.	2,4-Dimethylphenol	ND	
97.	Dimethyl phthalate	ND	
98.	Di-n-butyl phthalate	ND	
99.	1,4-Dinitrobenzene	ND	
100.	4,6-Dinitro-o-cresol	ND	
101.	2,4-Dinitrophenol	ND	
102.	2,4-Dinitrotoluene	ND	
103.	2,6-Dinitrotoluene	ND	
104.	Di-n-octyl phthalate	ND	
105.	Di-n-propylnitrosamine	ND	
106.	Diphenylamine	ND	
219.	Diphenylnitrosamine	NA	

Table 6-1 (Continued)

BDAT reference no.	Constituent	Detection status (mg/kg)	Believed to be present
	Semivolatile organics (continued)		
107.	1,2-Diphenylhydrazine	ND	
108.	Fluoranthene	0.73	
109.	Fluorene	ND	
110.	Hexachlorobenzene	ND	
111.	Hexachlorobutadiene	ND	
112.	Hexachlorocyclopentadiene	ND	
113.	Hexachloroethane	ND	
114.	Hexachlorophene	ND	
115.	Hexachloropropene	ND	
116.	Indeno(1,2,3-cd)pyrene	ND	
117.	Isosafrole	ND	
118.	Methapyrilene	ND	
119.	3-Methylcholanthrene	ND	
120.	4,4'-Methylenebis (2-chloroaniline)	ND	
36.	Methyl methanesulfonate	ND	
121.	Naphthalene	ND	
122.	1,4-Naphthoquinone	ND	
123.	1-Naphthylamine	ND	
124.	2-Naphthylamine	ND	
125.	p-Nitroaniline	ND	
126.	Nitrobenzene	ND	
127.	4-Nitrophenol	ND	
128.	N-Nitrosodi-n-butylamine	ND	
129.	N-Nitrosodiethylamine	ND	
130.	N-Nitrosodimethylamine	ND	
131.	N-Nitrosomethylethylamine	ND	
132.	N-Nitrosomorpholine	ND	
133.	N-Nitrosopiperidine	ND	
134.	n-Nitrosopyrrolidine	ND	
135.	5-Nitro-o-toluidine	ND	
136.	Pentachlorobenzene	ND	
137.	Pentachloroethane	ND	
138.	Pentachloronitrobenzene	ND	
139.	Pentachlorophenol	ND	
140.	Phenacetin	ND	
141.	Phenanthrene	ND	
142.	Phenol	ND	
220.	Phthalic anhydride	ND	
143.	2-Picoline	ND	
144.	Pronamide	ND	
145.	Pyrene	ND	
146.	Resorcinol	ND	

Table 6-1 (Continued)

BDAT reference no.	Constituent	Detection status (mg/kg)	Believed to be present
	Semivolatile organics (continued)		
147.	Safrole	ND	
148.	1,2,4,5-Tetrachlorobenzene	ND	
149.	2,3,4,6-Tetrachlorophenol	ND	
150.	1,2,4-Trichlorobenzene	ND	
151.	2,4,5-Trichlorophenol	ND	
152.	2,4,6-Trichlorophenol	ND	
153.	Tris(2,3-dibromopropyl) phosphate	ND	
	Metals		
154.	Antimony	5.03-294	
155.	Arsenic	10.2-470	
156.	Barium	24-400	
157.	Beryllium	0.15-8.08	
158.	Cadmium	1.35-4,988	
159.	Chromium (total)	<0.05-106,000	
221.	Chromium (hexavalent)	-	
160.	Copper	600-6,360	
161.	Lead	1.29-139,000	
162.	Mercury	0.0002-41	
163.	Nickel	<10-22,000	
164.	Selenium	0.068-600	
165.	Silver	2.5-71	
166.	Thallium	0.75-50	
167.	Vanadium	24-475	
168.	Zinc	3,900-320,000	
	Inorganics other than metals		
169.	Cyanide	<0.56	
170.	Fluoride	70.4	
171.	Sulfide	<5.6	
	Organochlorine pesticides		
172.	Aldrin	NA	
173.	alpha-BHC	NA	
174.	beta-BHC	NA	
175.	delta-BHC	NA	

Table 6-1 (Continued)

BDAT reference no.	Constituent	Detection status (mg/kg)	Believed to be present
	Organochlorine pesticides (continued)		
176.	gamma-BHC	NA	
177.	Chlordane	NA	
178.	DDD	NA	
179.	DDE	NA	
180.	DDT	NA	
181.	Dieldrin	NA	
182.	Endosulfan I	NA	
183.	Endosulfan II	NA	
184.	Endrin	NA	
185.	Endrin aldehyde	NA	
186.	Heptachlor	NA	
187.	Heptachlor epoxide	NA	
188.	Isodrin	NA	
189.	Kepone	NA	
190.	Methoxyclor	NA	
191.	Toxaphene	NA	
	Phenoxyacetic acid herbicides		
192.	2,4-Dichlorophenoxyacetic acid	NA	
193.	Silvex	NA	
194.	2,4,5-T	NA	
	Organophosphorous insecticides		
195.	Disulfoton	NA	
196.	Famphur	NA	
197.	Methyl parathion	NA	
198.	Parathion	NA	
199.	Phorate	NA	
	PCBs		
200.	Aroclor 1016	NA	
201.	Aroclor 1221	NA	
202.	Aroclor 1232	NA	
203.	Aroclor 1242	NA	
204.	Aroclor 1248	NA	
205.	Aroclor 1254	NA	
206.	Aroclor 1260	NA	

Table 6-1 (Continued)

BDAT reference no.	Constituent	Detection status (mg/kg)	Believed to be present
	Dioxins and furans		
207.	Hexachlorodibenzo-p-dioxins	NA	
208.	Hexachlorodibenzofurans	NA	
209.	Pentachlorodibenzo-p-dioxins	NA	
210.	Pentachlorodibenzofurans	NA	
211.	Tetrachlorodibenzo-p-dioxins	NA	
212.	Tetrachlorodibenzofurans	NA	
213.	2,3,7,8-Tetrachlorodibenzo-p-dioxin	NA	

ND = Not detected.

NA = Not analyzed.

X = Believed to be present based on an engineering analysis of the waste generating process.

Y = Believed to be present based on detection in treated residuals.

7. CALCULATION OF BDAT TREATMENT STANDARDS

This section shows the development of treatment standards for both subcategories of K061. EPA's methodology for developing treatment standards is discussed in detail in Section 1. In general, treatment standards for the regulated constituents are calculated by multiplying the average of the performance data representing BDAT by a factor (referred to as a variability factor) that accounts for treatment process variability, variations in the waste, and analytical variability. Below is a discussion of the treatment standards for the high and low zinc subcategories of K061 waste.

7.1 High Zinc Subcategory (greater than or equal to 15 percent zinc)

EPA is establishing both final and interim treatment standards for this subcategory. The final treatmen standard reflect performance achieved by BDAT, while the interim standards reflect performance achieved by best practicable treatment. Both are discussed below.

7.1.1 High Zinc Subcategory Final Standards

EPA has determined that BDAT for this subcategory represents treatment using high temperature metals recovery. EPA is promulgating a treatment standard of "No Land Disposal" based on this technology. An important part of EPA's rationale for establishing this standard rather than numerical performance values involves EPA's definition of "indigenous" as applied to secondary materials being reclaimed in industrial furnaces. EPA expects that a soon to be promulgated definition of "indigenous"will mean that HTMR residual slags generated in the treatment of K061 waste will not be classified as "K061 derived-from" wastes. Such a classification of the HTMR treated slag means that the Agency can establish a treatment standard of "no land disposal" for K061 nonwastewater based upon treatment using HTMR (i.e., by treating K061 nonwastewater in a HTMR unit, facilities would generate a residual slag that would not be classified as K061 waste. As a result, the facility would comply with the "no land disposal" requirement for K061 nonwastewater). EPA expects the definition of "indigneous" to be promulgated prior to the effective date of the "no land disposal" standards. If this definition is not promulgated by that date or if it results in classification of K061 waste as nonindigenous (which EPA doubts), EPA may revise the treatment standard for the High Zinc Subcategory of K061 waste.

7.1.2 High Zinc Subcategory Interim Final Standards

EPA is also promulgating interim final standards for the high zinc subcategory of K061 wastes. These treatment standards are based on best treatment available during the interim period before the no land disposal takes effect and are the same as the BDAT treatment standards for the low zinc subcategory of K061 waste. The calculation of these treatment standards is discussed below under the low zinc subcategory.

7.2 Low Zinc Subcategory (less than 15 percent zinc)

The performance data that EPA is using for the development of treatment standards for the low zinc subcategory of K061 waste is generated from stabilization of both K061 and F006 wastes. As discussed in Section 4, data for cadmium and lead reflect stabilization of K061 waste, while data for chromium and nickel reflect treatment of F006 wastes. EPA's rationale for transferring performance data from F006 wastes also is discussed in Section 4.

As a first step in developing the treatment standards, EPA evaluated the above performance data to ensure that any data representing poor design and poor operation were deleted and that all data were adjusted for analytical accuracy. These screening steps were performed earlier in connection with EPA's analysis of "substantial" treatment for K061 wastes in the low zinc subcategory (see Section 5). For stabilization of K061 wastes, no data were deleted because of poor design and poor operation; data deleted from the F006 performance data base are shown in Appendix F.

To develop the BDAT treatment standards, EPA averaged the performance data shown in Table 7-1 and multiplied these data by a variability factor, discussed earlier. The treatment standards shown in Table 7-1 represent instantaneous maximum concentrations that must be achieved as a preprequisite for land disposal of K061 wastes that are part of the low zinc subcategory. The concentrations are in mg/l (parts per million on a weight by volume basis), and represent values for the TCLP leachate.

Table 7-1 Regulated Constituents and Calculated Treatment Standards for K061 Waste

	Cadmium	Chromium	Lead	Nickel
	0.036	0.45	0.14	0.05
	0.053	0.09	0.064	0.03
	0.080	0.44	0.061	0.27
		0.89		0.02
		1.41		0.04
				<0.06
				0.11
				0.04
				0.02
Average	0.056	0.66	0.088	0.072
Number of samples	3	5	5	9
Variability factor	2.41	7.94	2.74	4.47
Treatment standard	0.14	5.2	0.24	0.32

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APPENDIX A

STATISTICAL METHODS

A.1 F Value Determination for ANOVA Test

As noted in Section 1.2, EPA is using the statistical method known as analysis of variance (ANOVA) to determine the level of performance that represents "best" treatment where more than one technology is demonstrated. This method provides a measure of the differences between data sets.

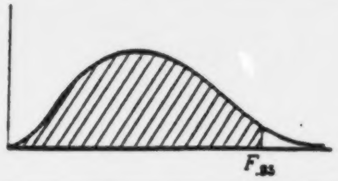
If the Agency found that the levels of performance for one or more technologies are not statistically different (i.e., the data sets are homogeneous), EPA would average the long-term performance values achieved by each technology and then multiply this value by the largest variability factor associated with any of the acceptable technologies. If EPA found that one technology performs significantly better (i.e., the data sets are not homogeneous), the "best" technology would be the technology that achieves the best level of performance, i.e., the technology with the lowest mean value.

To determine whether any or all of the treatment performance data sets are homogeneous using the analysis of variance method, it is necessary to compare a calculated "F value" to what is known as a "critical value." (See Table A-1.) These critical values are available in most statistics texts (see, for example, Statistical Concepts and Methods by Bhattacharyya and Johnson, 1977, John Wiley Publications, New York).

Table A-1

95th PERCENTILE VALUES FOR THE F DISTRIBUTION

n_1 = degrees of freedom for numerator
n_2 = degrees of freedom for denominator
(shaded area = .95)



n_2 \ n_1	1	2	3	4	5	6	8	12	16	20	30	40	50	100	∞
1	161.4	199.5	215.7	224.6	230.2	234.0	238.9	243.9	246.3	248.0	250.1	251.1	252.2	253.0	254.3
2	18.51	19.00	19.16	19.25	19.30	19.33	19.37	19.41	19.43	19.45	19.46	19.46	19.47	19.49	19.50
3	10.13	9.55	9.28	9.12	9.01	8.94	8.85	8.74	8.69	8.66	8.62	8.60	8.58	8.56	8.53
4	7.71	6.94	6.59	6.39	6.26	6.16	6.04	5.91	5.84	5.80	5.75	5.71	5.70	5.66	5.63
5	6.61	5.79	5.41	5.19	5.05	4.95	4.82	4.68	4.60	4.56	4.50	4.46	4.44	4.40	4.36
6	5.99	5.14	4.76	4.53	4.39	4.28	4.15	4.00	3.92	3.87	3.81	3.77	3.75	3.71	3.67
7	5.59	4.74	4.35	4.12	3.97	3.87	3.73	3.57	3.49	3.44	3.38	3.34	3.32	3.28	3.23
8	5.32	4.46	4.07	3.84	3.69	3.58	3.44	3.28	3.20	3.15	3.08	3.05	3.03	2.98	2.93
9	5.12	4.26	3.86	3.63	3.48	3.37	3.23	3.07	2.98	2.93	2.86	2.82	2.80	2.76	2.71
10	4.96	4.10	3.71	3.48	3.33	3.22	3.07	2.91	2.82	2.77	2.70	2.67	2.64	2.59	2.54
11	4.84	3.98	3.59	3.36	3.20	3.09	2.95	2.79	2.70	2.65	2.57	2.53	2.50	2.45	2.40
12	4.75	3.89	3.49	3.26	3.11	3.00	2.85	2.69	2.60	2.54	2.46	2.42	2.40	2.35	2.30
13	4.67	3.81	3.41	3.18	3.03	2.92	2.77	2.60	2.51	2.46	2.38	2.34	2.32	2.26	2.21
14	4.60	3.74	3.34	3.11	2.96	2.85	2.70	2.53	2.44	2.39	2.31	2.27	2.24	2.19	2.13
15	4.54	3.68	3.29	3.06	2.90	2.79	2.64	2.48	2.39	2.33	2.25	2.21	2.18	2.12	2.07
16	4.49	3.63	3.24	3.01	2.85	2.74	2.59	2.42	2.33	2.28	2.20	2.16	2.13	2.07	2.01
17	4.45	3.59	3.20	2.96	2.81	2.70	2.55	2.38	2.29	2.23	2.15	2.11	2.08	2.02	1.96
18	4.41	3.55	3.16	2.93	2.77	2.66	2.51	2.34	2.25	2.19	2.11	2.07	2.04	1.98	1.92
19	4.38	3.52	3.13	2.90	2.74	2.63	2.48	2.31	2.21	2.15	2.07	2.02	2.00	1.94	1.88
20	4.35	3.49	3.10	2.87	2.71	2.60	2.45	2.28	2.18	2.12	2.04	1.99	1.96	1.90	1.84
22	4.30	3.44	3.05	2.82	2.66	2.55	2.40	2.23	2.13	2.07	1.98	1.93	1.91	1.84	1.78
24	4.26	3.40	3.01	2.78	2.62	2.51	2.36	2.18	2.09	2.03	1.94	1.89	1.86	1.80	1.73
26	4.23	3.37	2.98	2.74	2.59	2.47	2.32	2.15	2.05	1.99	1.90	1.85	1.82	1.76	1.69
28	4.20	3.34	2.95	2.71	2.56	2.45	2.29	2.12	2.02	1.96	1.87	1.81	1.78	1.72	1.65
30	4.17	3.32	2.92	2.69	2.53	2.42	2.27	2.09	1.99	1.93	1.84	1.79	1.76	1.69	1.62
40	4.08	3.23	2.84	2.61	2.45	2.34	2.18	2.00	1.90	1.84	1.74	1.69	1.66	1.59	1.51
50	4.03	3.18	2.79	2.56	2.40	2.29	2.13	1.95	1.85	1.78	1.69	1.63	1.60	1.52	1.44
60	4.00	3.15	2.76	2.53	2.37	2.25	2.10	1.92	1.81	1.75	1.65	1.59	1.56	1.48	1.39
70	3.98	3.13	2.74	2.50	2.35	2.23	2.07	1.89	1.79	1.72	1.62	1.56	1.53	1.45	1.35
80	3.96	3.11	2.72	2.48	2.33	2.21	2.05	1.88	1.77	1.70	1.60	1.54	1.51	1.42	1.32
100	3.94	3.09	2.70	2.46	2.30	2.19	2.03	1.85	1.75	1.68	1.57	1.51	1.48	1.39	1.28
150	3.91	3.06	2.67	2.43	2.27	2.16	2.00	1.82	1.71	1.64	1.54	1.47	1.44	1.34	1.22
200	3.89	3.04	2.65	2.41	2.26	2.14	1.98	1.80	1.69	1.62	1.52	1.45	1.42	1.32	1.19
400	3.86	3.02	2.62	2.39	2.23	2.12	1.96	1.78	1.67	1.60	1.49	1.42	1.38	1.28	1.13
∞	3.84	2.99	2.60	2.37	2.21	2.09	1.94	1.75	1.64	1.57	1.46	1.40	1.32	1.24	1.00

Where the F value is less than the critical value, all treatment data sets are homogeneous. If the F value exceeds the critical value, it is necessary to perform a "pair wise F" test to determine if any of the sets are homogeneous. The "pair wise F" test must be done for all of the various combinations of data sets using the same method and equation as the general F test.

The F value is calculated as follows:

(i) All data are natural logtransformed.

(ii) The sum of the data points for each data set is computed (T_i).

(iii) The statistical parameter known as the sum of the squares between data sets (SSB) is computed:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right) \right] - \left[\frac{\left(\sum_{i=1}^{k} T_i \right)^2}{N} \right]$$

where:

k = number of treatment technologies
n_i = number of data points for technology i
N = number of data points for all technologies
T_i = sum of natural logtransformed data points for each technology.

(iv) The sum of the squares within data sets (SSW) is computed:

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

where:

$x_{i,j}$ = the natural logtransformed observations (j) for treatment technology (i).

(v) The degrees of freedom corresponding to SSB and SSW are calculated. For SSB, the degree of freedom is given by k-1. For SSW, the degree of freedom is given by N-k.

(vi) Using the above parameters, the F value is calculated as follows:

$$F = \frac{MSB}{MSW}$$

where:

MSB = SSB/(k-1) and
MSW = SSW/(N-k).

A computational table summarizing the above parameters is shown below.

Computational Table for the F Value

Source	Degrees of freedom	Sum of squares	Mean square	F value
Between	k-1	SSB	MSB = SSB/k-1	MSB/MSW
Within	N-k	SSW	MSW = SSW/N-k	

Below are three examples of the ANOVA calculation. The first two represent treatment by different technologies that achieve statistically similar treatment; the last example represents a case in which one technology achieves significantly better treatment than the other technology.

Example 1
Methylene Chloride

Steam stripping				Biological treatment			
Influent ($\mu g/l$)	Effluent ($\mu g/l$)	ln(effluent)	$[\ln(\text{effluent})]^2$	Influent ($\mu g/l$)	Effluent ($\mu g/l$)	ln(effluent)	$[\ln(\text{effluent})]^2$
1550.00	10.00	2.30	5.29	1960.00	10.00	2.30	5.29
1290.00	10.00	2.30	5.29	2568.00	10.00	2.30	5.29
1640.00	10.00	2.30	5.29	1817.00	10.00	2.30	5.29
5100.00	12.00	2.48	6.15	1640.00	26.00	3.26	10.63
1450.00	10.00	2.30	5.29	3907.00	10.00	2.30	5.29
4600.00	10.00	2.30	5.29				
1760.00	10.00	2.30	5.29				
2400.00	10.00	2.30	5.29				
4800.00	10.00	2.30	5.29				
12100.00	10.00	2.30	5.29				
Sum:							
-	-	23.18	53.76	-	-	12.46	31.79
Sample Size:							
10	10	10	-	5	5	5	-
Mean:							
3669	10.2	2.32	-	2378	13.2	2.49	-
Standard Deviation:							
3328.67	.63	.06	-	923.04	7.15	.43	-
Variability Factor:							
	1.15	-	-	-	2.48	-	-

ANOVA Calculations:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right) \right] - \left[\frac{\left(\sum_{i=1}^{k} T_i \right)^2}{N} \right]$$

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

$$MSB = SSB/(k-1)$$

$$MSW = SSW/(N-k)$$

Example 1 (Continued)

$F = MSB/MSW$

where:

k = number of treatment technologies

n_i = number of data points for technology i

N = number of natural logtransformed data points for all technologies

T_i = sum of logtransformed data points for each technology

X_{ij} = the nat. logtransformed observations (j) for treatment technology (i)

$n_1 = 10$, $n_2 = 5$, $N = 15$, $k = 2$, $T_1 = 23.18$, $T_2 = 12.46$, $T = 35.64$, $T^2 = 1270.21$

$T_1^2 = 537.31$ $T_2^2 = 155.25$

$$SSB = \left[\frac{537.31}{10} + \frac{155.25}{5}\right] - \frac{1270.21}{15} = 0.10$$

$$SSW = (53.76 + 31.79) - \left[\frac{537.31}{10} + \frac{155.25}{5}\right] = 0.77$$

$MSB = 0.10/1 = 0.10$

$MSW = 0.77/13 = 0.06$

$$F = \frac{0.10}{0.06} = 1.67$$

ANOVA Table

Source	Degrees of freedom	SS	MS	F value
Between(B)	1	0.10	0.10	1.67
Within(W)	13	0.77	0.06	

The critical value of the F test at the 0.05 significance level is 4.67. Since the F value is less than the critical value, the means are not significantly different (i.e., they are homogeneous).

Note: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

Example 2
Trichloroethylene

Steam stripping Influent (μg/l)	Effluent (μg/l)	ln(effluent)	[ln(effluent)]^2	Biological treatment Influent (μg/l)	Effluent (μg/l)	ln(effluent)	[ln(effluent)]^2
1650.00	10.00	2.30	5.29	200.00	10.00	2.30	5.29
5200.00	10.00	2.30	5.29	224.00	10.00	2.30	5.29
5000.00	10.00	2.30	5.29	134.00	10.00	2.30	5.29
1720.00	10.00	2.30	5.29	150.00	10.00	2.30	5.29
1560.00	10.00	2.30	5.29	484.00	16.25	2.79	7.78
10300.00	10.00	2.30	5.29	163.00	10.00	2.30	5.29
210.00	10.00	2.30	5.29	182.00	10.00	2.30	5.29
1600.00	27.00	3.30	10.89				
204.00	85.00	4.[illegible]	19.71				
160.00	10.00	2.[illegible]	5.29				
Sum:							
-	-	26.14	72.92	-	-	16.59	39.52
Sample Size:							
10	10	10	-	7	7	7	-
Mean:							
2760	19.2	2.61	-	220	10.89	2.37	-
Standard Deviation:							
3209.6	23.7	.71	-	120.5	2.36	.19	-
Variability Factor:							
-	3.70	-	-	-	1.53	-	-

ANOVA Calculations:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right) \right] - \left[\frac{\left(\sum_{i=1}^{k} T_i \right)^2}{N} \right]$$

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

MSB = SSB/(k-1)

MSW = SSW/(N-k)

Example 2 (Continued)

$F = MSB/MSW$

where:

k = number of treatment technologies

n_i = number of data points for technology i

N = number of data points for all technologies

T_i = sum of natural logtransformed data points for each technology

X_{ij} = the natural logtransformed observations (j) for treatment technology (i)

$N_1 = 10$, $N_2 = 7$, $N = 17$, $k = 2$, $T_1 = 26.14$, $T_2 = 16.59$, $T = 42.73$, $T^2 = 1825.85$, $T_1^2 = 683.30$,

$T_2^2 = 275.23$

$$SSB = \left(\frac{683.30}{10} + \frac{275.23}{7}\right) - \frac{1825.85}{17} = 0.25$$

$$SSW = (72.92 + 39.52) - \left(\frac{683.30}{10} + \frac{275.23}{7}\right) = 4.79$$

$MSB = 0.25/1 = 0.25$

$MSW = 4.79/15 = 0.32$

$$F = \frac{0.25}{0.32} = 0.78$$

ANOVA Table

Source	Degrees of freedom	SS	MS	F value
Between(B)	1	0.25	0.25	0.78
Within(W)	15	4.79	0.32	

The critical value of the F test at the 0.05 significance level is 4.54. Since the F value is less than the critical value, the means are not significantly different (i.e., they are homogeneous).

Note: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

Example 3
Chlorobenzene

Activated sludge followed by carbon adsorption				Biological treatment			
Influent (μg/l)	Effluent (μg/l)	ln(effluent)	[ln(effluent)]^2	Influent (μg/l)	Effluent (μg/l)	ln(effluent)	ln[(effluent)]^2
7200.00	80.00	4.38	19.18	9206.00	1083.00	6.99	48.86
6500.00	70.00	4.25	18.06	16646.00	709.50	6.56	43.03
6075.00	35.00	3.56	12.67	49775.00	460.00	6.13	37.58
3040.00	10.00	2.30	5.29	14731.00	142.00	4.96	24.60
				3159.00	603.00	6.40	40.96
				6756.00	153.00	5.03	25.30
				3040.00	17.00	2.83	8.01
Sum:							
-	-	14.49	55.20	-	-	38.90	228.34
Sample Size:							
4	4	4	-	7	7	7	-
Mean:							
5703	49	3.62	-	14759	452.5	5.56	-
Standard Deviation:							
1835.4	32.24	.95		16311.86	379.04	1.42	-
Variability Factor:							
-	7.00	-	-	-	15.79	-	-

ANOVA Calculations:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right) \right] - \left[\frac{\left(\sum_{i=1}^{k} T_i \right)^2}{N} \right]$$

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

$MSB = SSB/(k-1)$

$MSW = SSW/(N-k)$

$F = MSB/MSW$

Example 3 (Continued)

where,

k = number of treatment technologies

n_i = number of data points for technology i

N = number of data points for all technologies

T_i = sum of natural logtransformed data points for each technology

X_{ij} = the natural logtransformed observations (j) for treatment technology (i)

$N_1 = 4$, $N_2 = 7$, $N = 11$, $k = 2$, $T_1 = 14.49$, $T_2 = 38.90$, $T = 53.39$, $T^2 = 2850.49$, $T_1^2 = 209.96$

$T_2^2 = 1513.21$

$$SSB = \left[\frac{209.96}{4} + \frac{1513.21}{7}\right] - \frac{2850.49}{11} = 9.52$$

$$SSW = (55.20 + 228.34) - \left[\frac{209.96}{4} + \frac{1513.21}{7}\right] = 14.88$$

$MSB = 9.52/1 = 9.52$

$MSW = 14.88/9 = 1.65$

$F = 9.52/1.65 = 5.77$

ANOVA Table

Source	Degrees of freedom	SS	MS	F value
Between(B)	1	9.53	9.53	5.77
Within(W)	9	14.89	1.65	

The critical value of the F test at the 0.05 significance level is 5.12. Since the F value is larger than the critical value, the means are significantly different (i.e., they are heterogeneous). Activated sludge followed by carbon adsorption is "best" in this example because the mean of the long-term performance value, i.e., the effluent concentration, is lower.

Note: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

A.2 Variability Factor

$$VF = \frac{C_{99}}{Mean}$$

where:

VF = estimate of daily maximum variability factor determined from a sample population of daily data;

C_{99} = estimate of performance values for which 99 percent of the daily observations will be below. C_{99} is calculated using the following equation: $C_{99} = Exp(y + 2.33\ Sy)$ where y and Sy are the mean and standard deviation, respectively, of the logtransformed data; and

Mean = average of the individual performance values.

EPA is establishing this figure as an instantaneous maximum because the Agency believes that on a day-to-day basis the waste should meet the applicable treatment standards. In addition, establishing this requirement makes it easier to check compliance on a single day. The 99th percentile is appropriate because it accounts for almost all process variability.

In several cases, _all_ the results from analysis of the residuals from BDAT treatment are found at concentrations less than the detection limit. In such cases, all the actual concentration values are considered unknown and, hence, cannot be used to estimate the variability factor of the analytical results. Below is a description of EPA's approach for calculating the variability factor for such cases with all concentrations below the detection limit.

It nas been postulated as a general rule that a lognormal distribution adequately describes the variation among concentrations. Agency data show that the treatment residual concentrations are distributed approximately lognormally. Therefore, the lognormal model has been used routinely in the EPA development of numerous regulations in the Effluent Guidelines program and is being used in the BDAT program. The variability factor (VF) was defined as the ratio of the 99th percentile (C_{99}) of the lognormal distribution to its arithmetic mean (Mean), as follows:

$$VF = \frac{C_{99}}{Mean}. \qquad (1)$$

The relationship between the parameters of the lognormal distribution and the parameters of the normal distribution created by taking the natural logarithms of the lognormally distributed concentrations can be found in most mathematical statistics texts (see, for example, Distribution in Statistics-Volume 1 by Johnson and Kotz, 1970). The mean of the lognormal distribution can be expressed in terms of the mean (μ) and standard deviation (σ) of the normal distribution as follows:

$$C_{99} = \text{Exp}\ (\mu + 2.33\sigma) \qquad (2)$$

$$Mean = \text{Exp}\ (\mu + 0.5\sigma^2). \qquad (3)$$

By substituting (2) and (3) in (1), the variability factor can then be expressed in terms of σ as follows:

$$VF = \text{Exp}\ (2.33\ \sigma - 0.5\sigma^2). \qquad (4)$$

For residuals with concentrations that are not all below the detection limit, the 99th percentile and the mean can be estimated from the actual analytical data and, accordingly, the variability factor (VF) can be estimated using equation (1). For residuals with concentrations that are below the detection limit, the above equations can be used in conjunction with the following assumptions to develop a variability factor.

- Assumption 1: The actual concentrations follow a lognormal distribution. The upper limit (UL) is equal to the detection limit. The lower limit (LL) is assumed to be equal to one-tenth of the detection limit. This assumption is based on the fact that data from well-designed and well-operated treatment systems generally fall within one order of magnitude.
- Assumption 2: The natural logarithms of the concentrations have a normal distribution with an upper limit equal to ln (UL) and a lower limit equal to ln (LL).
- Assumption 3: The standard deviation (σ) of the normal distribution is approximated by:

$$\sigma = [\ln(UL) - \ln(LL)] / [(2)(2.33)]$$
$$= [\ln(UL/LL)] / 4.66. \quad (5)$$

(Note that when LL = (0.1)(UL) as in Assumption 1, then $\sigma = (\ln 10) / 4.66 = 0.494$.)

Substitution of the σ value from equation (5) into equation (4) yields the variability factor, VF, as shown:

$$VF = 2.8. \quad (6)$$

APPENDIX B

ANALYTICAL QA/QC

Tables B-1 through B-8 of this appendix present quality assurance/quality control (QA/QC) information for the available performance data presented in Section 4 and identify the methods and procedures used for analyzing the constituents to be regulated. The QA/QC information includes matrix spike recovery data that are used for adjusting the analytical results for accuracy. The adjusted analytical results referred to as accuracy-corrected concentrations, generally are used for comparing the performance of one technology to that of another and for calculating treatment standards for those constituents to be regulated.

Table B-1 Analytical Methods

Analytical method	Method number	Reference
Metals		
Acid Digestion of Aqueous Samples and Extracts for Total Metals for Analysis by Flame Atomic Absorption Spectroscopy (AA) or Inductively Coupled Plasma Spectroscopy (ICP)	3010	1
Acid Digestion of Aqueous Samples and Extracts for Total Metals for Analysis by Furnace Atomic Absorption Spectroscopy (AA)	3020	1
Acid Digestion of Sediments, Sludges, and Soils	3050	1
Inductively Coupled Plasma Atomic Emission Spectroscopy (Cadmium, Chromium, Lead, Zinc)	6010	1
Mercury in Liquid Waste (Manual Cold-Vapor Technique)	7471	1
Toxicity Characteristic Leaching Procedure (TCLP)	51 FR 40643	2

References:

1. USEPA 1986b.

2. USEPA 1986a.

Table B-2 Specific Procedures or Equipment Used in Analysis of Metals When Alternative or Equivalents Are Allowed in the SW-646 Methods

Analysis	SW-846 Method	Equipment	Alternative or equivalent allowed by SW-846 methods	Specific procedures or equipment used
Inductively coupled plasma atomic emission spectroscopy	6010	Jarrell Ash 1140	• Operate equipment following instructions provided by instument's manufacturer. • For operation with organic solvents, auxiliary argon gas inlet is recommended.	• Equipment operated using procedures specified in the Jarrell Ash (JA) 1140 Operator's Manual. • Auxiliary argon gas was not required for sample matrix analyzed.
Mercury	7471	Perkin Elmer 50A	• Operate equipment following instructions provided by instrument's manufacturer. • Cold vapor apparatus is described in SW-846 or an equivalent apparatus may be used. • Sample may be prepared using the water bath method or the autoclave method described in SW-846.	• Equipment operated using procedures specified Perkin Elmer 50A Instructions Manual. Mercury was analyzed by cold vapor method using the apparatus as specified in SW-846 except there was no scrubber. Samples were prepared using the water bath method.

Table B-2 (Continued)

Analysis	SW-846 Method	Equipment	Alternative or equivalent allowed by SW-846 methods	Specific procedures or equipment used
Acid digestion	3010	-	• Digest 100 ml of sample in a conical beaker.	• Initial sample volume of 50 ml is digested in Griffin straight-side beakers. All acids and peroxides are halved.

Table B-3. Duplicate Analysis for the Total Composition
Sample Point 6: Residual Slag Material[a]

BDAT metals	Sample Set 1 (mg/kg)	Sample Set 1 (mg/kg)	Relative percent difference (RPD)[b]
Chromium	662	752	13
Lead	1,720	1,780	3
Zinc	24,300	25,800	6

[a] Duplicates not run constitutes not detected in any of the treated samples (cadmium, mercury).

[b] RPD = [(S1-S2)/((S1+S2)/2)] x 100%, where S1 is the larger of the two observed values.

Table B-4. Duplicate Analysis for Matrix Spikes for TCLP Extract for Sample Point 6: Residual Slag Material

BDAT metals	Sample Set 4 (ug/l)	Sample Set 4 (ug/l)	Relative percent difference (RPD)[a]
Chromium	662	752	13
Lead	1,720	1,780	3
Zinc	24,300	25,800	6

[a] RPD = [(S1-S2)/((S1+S2)/2)] x 100%, where S1 is the larger of the two observed values.

Table B-5 BDAT Constituents for Spiking Mixture for Total Composition Sample and for TCLP Extract Sample

Constituent	Total composition spike concentration (mg/Kg)	TCLP extract spike concentration (ug/l)
Metals		
Cadmium	2.5	25
Chromium	2,000	50
Lead	500	25
Mercury	0.5	1
Zinc	6,000	1,000

Table B-6 Matrix Spike Recoveries for Treated Waste Total Concentrations and Accuracy-Correction Factors for High Temperature Metals Recovery

		Sample			Sample duplicate			
BDAT constituent	Original amount found (mg/kg)	Spike added (mg/kg)	Spike result (mg/kg)	Percent recovery[a]	Spike added (mg/kg)	Spike result (mg/kg)	Percent recovery[a]	Correction factor
Cadmium	<1.5	2.5	<1.5	NC	2.5	2.4	96	1.04
Chromium	978	2,000	2,970	100	2,000	2,870	95	1.05
Lead	365	500	683	64	500	705	68	1.56
Mercury	<0.1	0.5	0.5	100	0.5	0.5	100	1.00
Zinc	4,680	6,000	9,770	85	6,000	9,950	88	1.18

NC = Not Calculable.

[a] Percent recovery = [(spike result - original amount)/spike added] x 100.

Table B-7 Matrix Spike Recovery for TCLP Extract for Treated Waste and Accuracy-Correction Factors for High Temperature Metals Recovery

		Sample			Sample duplicate		
BDAT constituent	Original sample (ug/l)	Spike added (ug/l)	Spike result (ug/l)	Percent recovery[a]	Spike result (ug/l)	Percent recovery[a]	Correction factor
Cadmium	4.2	25	26	87	27	91	1.15
Chromium	<4.0	50	35	70	34	68	1.47
Lead	<5.0	25	22	88	19	76	1.32
Mercury	<0.2	1.0	0.9	90	1.1	110	1.11
Zinc	2,640	10,000	12,600	100	12,400	98	1.02

[a] Percent recovery = [(spike result - original amount)/spike added] 100.

APPENDIX C

KILN TEMPERATURE STRIP CHARTS

[This information has been claimed CBI by
the facility pursuant to 40 CFR Part 2.]

APPENDIX D

COMPARISON OF HIGH TEMPERATURE METALS RECOVERY WITH STABILIZATION FOR K061 WASTE

Table D-1 shows results of the ANOVA test when comparing high temperature metals recovery with stabilization for the constituents being regulated in K061. The ANOVA test is discussed in Appendix A.

Table D-1 Comparison of High Temperature Metals Recovery with Stabilization for K061

Constituent	Source	D.F.	Sum of Squares	Mean of Squares	Computed F	Tabulated F	Decision
Cadmium	**Between groups**	1	2.7298	2.7298	1.3389	5.32	No statistical difference
	Within groups	8	16.3102	2.0388			
	Total	9	19.0400				
Chromium	Between groups	1	0.0640	0.0640	0.0649	5.32	No statistical difference
	Within groups	8	7.8920	0.9865			
	Total	9	7.9560				
Lead	Between groups	1	4.2129	4.2129	5.2368	5.32	There is a significant difference between the two. High temperature metals recovery is better
	Within groups	8	6.4358	0.8045			
	Total	9	10.6487				
Nickel	Between groups	1	23.2143	23.2143	19.7298	5.32	There is a difference between the two. Stabilization is better
	Within groups	8	10.5895	1.1766			
	Total	9	33.8038				

APPENDIX E

METHOD OF MEASUREMENT FOR THERMAL CONDUCTIVITY

The comparative method of measuring thermal conductivity has been proposed as an ASTM test method under the name "Guarded, Comparative, Longitudinal Heat Flow Technique." A thermal heat flow circuit is used that is the analog of an electrical circuit with resistances in series. A reference material is chosen to have a thermal conductivity close to that estimated for the sample. Reference standards (also known as heat meters) having the same cross-sectional dimensions as the sample are placed above and below the sample. An upper heater, a lower heater, and a heat sink are added to the "stack" to complete the heat flow circuit. See Figure E-1.

The temperature gradients (analogous to potential differences) along the stack are measured with type K (chromel/alumel) thermocouples placed at known separations. The thermocouples are placed into holes or grooves in the references and also in the sample whenever the sample is thick enough to accommodate them.

For molten samples, pastes, greases, and other materials that must be contained, the material is placed into a cell consisting of a top and bottom of Pyrex 7740 and a containment ring of marinite. The sample is 2 inches in diameter and 0.5 inch thick. Thermocouples are not placed into the sample; rather, the temperatures measured in the Pyrex are extrapolated to give the temperature at the top and bottom surfaces of the sample material. The Pyrex disks also serve as the thermal conductivity reference material.

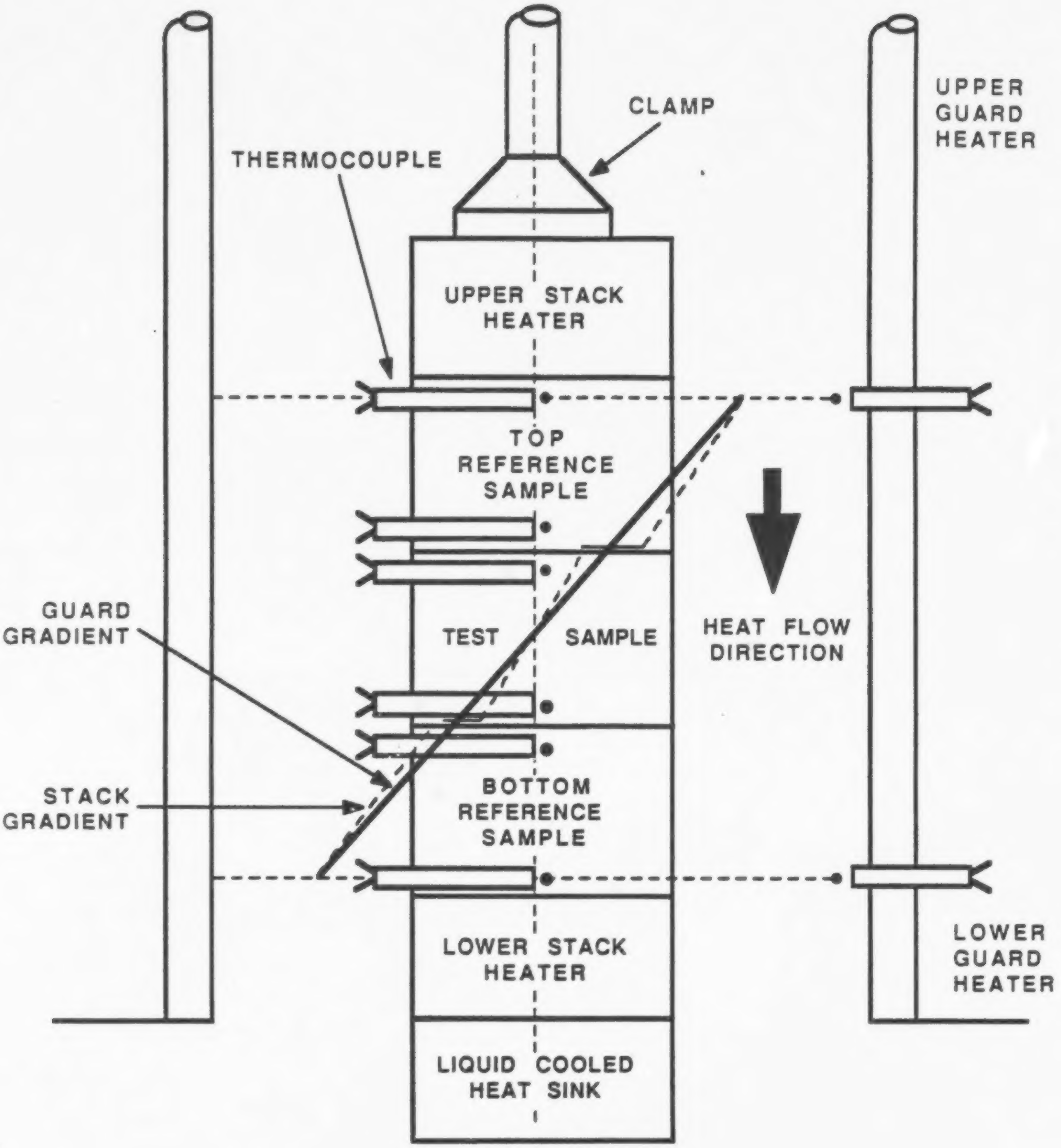

UPPER GUARD HEATER
CLAMP
THERMOCOUPLE
UPPER STACK HEATER
TOP REFERENCE SAMPLE
GUARD GRADIENT
TEST SAMPLE
HEAT FLOW DIRECTION
STACK GRADIENT
BOTTOM REFERENCE SAMPLE
LOWER STACK HEATER
LOWER GUARD HEATER
LIQUID COOLED HEAT SINK

FIGURE E-1 SCHEMATIC DIAGRAM OF THE COMPARATIVE METHOD

The stack is clamped with a reproducible load to ensure intimate contact between the components. To produce a linear flow of heat down the stack and reduce the amount of heat that flows radially, a guard tube is placed around the stack, and the intervening space is filled with insulating grains or powder. The temperature gradient in the guard is matched to that in the stack to further reduce radial heat flow.

The comparative method is a steady-state method of measuring thermal conductivity. When equilibrium is reached, the heat flux (analogous to current flow) down the stack can be determined from the references. The heat into the sample is given by

$$Q_{in} = \lambda_{top} (dT/dx)_{top}$$

and the heat out of the sample is given by

$$Q_{out} = \lambda_{bottom} (dT/dx)_{bottom}$$

where

λ = thermal conductivity

dT/dx = temperature gradient

and top refers to the upper reference, while bottom refers to the lower reference. If the heat were confined just to flow down the stack, then Q_{in} and Q_{out} would be equal. If Q_{in} and Q_{out} are in reasonable agreement, the average heat flow is calculated from

$$Q = (Q_{in} + Q_{out})/2.$$

The sample thermal conductivity is then found from

$$\lambda_{sample} = Q/(dT/dx)_{sample}.$$

APPENDIX F

DELETION OF PERFORMANCE DATA FOR F006 WASTES

Table F-1 shows the deletion of data points from F006 stabilization performance data.

Table F-1 Deletion of Stabilization Performance Data for F006 Wastes

Source	Mix ratio[a]	Metal concentrations (ppm)										
		Arsenic	Barium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Unknown												
Unstabilized												
As received		-	36.4	1.3	1270	40.2	35.5	-	435	-	2.3	1560
TCLP		<0.01	0.08	0.01	0.34	0.15	0.26	<0.001	0.71	<0.01	0.01	0.16
Stabilized												
TCLP	0.2	<0.01[b]	0.122[c]	0.011[d]	0.587[c]	0.206[c]	0.336[c]	<0.001[b]	0.046	0.058[b]	0.035[d]	0.034
Autopart manufacturing												
Unstabilized												
As received		-	21.6	31.3	755	7030	409	-	989	-	6.62	4020
TCLP		<0.01	0.32	2.21	0.76	368	10.7	<0.001	22.7	<0.01	0.14	219
Stabilized												
TCLP	0.2	<0.01[e]	0.51[e]	0.53[e]	0.46[e]	5.56[e]	0.448[e]	<0.001[e]	1.73[e]	0.058[e]	0.035[e]	42.1[e]
TCLP	0.5	<0.01[b]	0.458[c]	0.010	0.454	0.27	0.389	<0.001[b]	0.033	0.118[b]	0.059	0.010
Aircraft overhauling												
Unstabilized												
As received		-	85.5	67.3	716	693	25.7	-	259	-	39	631
TCLP		0.01	1.41	1.13	0.43	1.33	0.26	<0.001	1.1	<0.01	0.02	5.41
Stabilized												
TCLP	0.2	<0.01[b]	0.337	0.064	0.092	1.69[c]	0.336[c]	<0.001[b]	0.265	0.067[b]	0.236[c]	0.057
TCLP	0.5	<0.01[e]	0.338[e]	0.020[e]	0.234[e]	1.99[e]	0.443[e]	<0.001[e]	0.167[e]	0.128[e]	0.059[e]	0.030[e]
Aerospace manufacturing (F006 & F007 mixture)[f]												
Unstabilized												
As received		-	0.74	1.69	12.9	18.6	11.4	-	234	-	6.26	8.86
TCLP		<0.01	0.83	0.66	7.58	4.12	6.86	0.003	158	<0.01	1.64	2.28
Stabilized												
TCLP	1.0	<0.01	0.530	<0.01	0.46	0.237	0.224	<0.001	5.00	0.16	0.106	0.057
TCLP	1.5	<0.01	1.29	0.010	0.398	0.205	0.389	<0.001	2.74	0.232	0.177	0.030

Table F-1 (Continued)

Source	Mix ratio[a]	Metal concentrations (ppm)										
		Arsenic	Barium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Zinc plating												
Unstabilized												
As received		-	17.2	1.30	110	1510	88.5		37	-	9.05	90200
TCLP		-	0.84	0.22	0.18	4.6	0.45	<0.001	0.52	-	0.16	2030
Stabilized												
TCLP	0.2	<0.01[e]	0.204[e]	0.011[e]	0.263[e]	0.309[e]	0.336[e]	<0.001[e]	0.115[e]	0.077[e]	0.035[e]	06.5[e]
TCLP	0.5	<0.01[b]	0.251	0.010	0.351[c]	0.206	0.367[g]	<0.001[b]	0.022	0.162[b]	0.047	0.004
Unknown												
Unstabilized												
As received		-	14.3	720	12200	160	52	-	701	-	5.28	35900
TCLP		<0.01	0.38	23.6	25.3	1.14	0.45	<0.001	9.78	<0.01	0.08	867
Stabilized												
TCLP	0.2	<0.01[e]	0.316[e]	3.424[e]	0.288[e]	0.206[e]	0.269[e]	<0.001[e]	0.610[e]	0.034[e]	0.047[e]	3.88[e]
TCLP	0.5	<0.01[b]	0.207	0.010	0.44	0.313	0.389[g]	<0.001[b]	0.046	0.104[b]	0.071[g]	0.030
Small engine manufacturing												
Unstabilized												
As received		-	24.5	7.28	3100	1220	113	-	19400	-	4.08	27800
TCLP		<0.01	0.07	0.3	38.7	31.7	3.37	0.003	730	<0.01	0.12	1200
Stabilized												
TCLP	0.2	<0.01[e]	0.306[e]	0.021[e]	0.242[e]	0.216[e]	0.336[e]	<0.001[e]	18.9[e]	0.048[e]	0.035[e]	41.4[e]
TCLP	0.5	<0.01[b]	0.360[c]	0.010	0.889	0.206	0.389	<0.001[b]	0.055	0.128[b]	0.059	0.040
Circuit board manufacturing												
Unstabilized												
As received		-	12.6	5.39	42900	10600	156	-	13000	-	12.5	120
TCLP		<0.01	0.04	0.06	360	8.69	1.0	<0.001	152	<0.01	0.05	0.62
Stabilized												
TCLP	0.2	<0.01[e]	0.041[e]	0.011[e]	3.45[e]	0.412[e]	0.336[e]	<0.001[e]	0.46[e]	0.034[e]	0.035[e]	0.023[e]
TCLP	0.5	<0.01[b]	0.153[c]	0.010	1.416	0.454	0.410	<0.001[b]	0.111	0.031[b]	0.059[c]	0.020

Table F-1 (Continued)

Source	Mix ratio[a]	Metal concentrations (ppm) Arsenic	Barium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Unknown												
Unstabilized												
As received		-	15.3	5.81	47.9	17600	169	-	23700	-	8.11	15700
TCLP		<0.01	0.53	0.18	0.04	483	4.22	<0.001	644	<0.01	0.31	650
Stabilized												
TCLP	0.2	<0.01[e]	0.326[e]	0.011[e]	0.115[e]	0.515[e]	0.347[e]	<0.001[e]	18.1[e]	0.067[e]	0.035[e]	5.18[e]
TCLP	0.5	<0.01[b]	0.294	0.010	0.234[c]	0.346	0.400	<0.001[b]	0.044	0.081[b]	0.059	0.020
Unknown												
Unstabilized												
As received		-	19.2	5.04	644	27400	24500	-	5730	-	19.1	322
TCLP		0.88	0.28	0.01	0.01	16.9	50.2	<0.001	16.1	<0.45	<0.01	1.29
Stabilized												
TCLP	0.2	<0.02[e]	0.194[e]	<0.01[e]	0.035[e]	3.28[e]	2.677[e]	<0.001[e]	1.25[e]	<0.01[e]	<0.01[e]	0.080[e]
TCLP	0.5	<0.02[b]	0.087	<0.010[d]	0.256[d]	0.497	0.291	<0.001[b]	0.022	<0.01[b]	<0.01[d]	<0.01

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[a] Mix ratio = $\frac{\text{weight of reagent}}{\text{weight of waste}}$

[b] Data deleted because no untreated total composition or TCLP value is available to demonstrate treatment.

[c] Data deleted because treated TCLP value is greater than untreated TCLP value.

[d] Data deleted because untreated TCLP value is too low to show meaningful treatment.

[e] Data deleted because of less effective design and operation.

[f] Data deleted because untreated waste is a mixture of F006 and F007.

[g] Data deleted because reduction in leachability is attributed to dilution rather than treatment.

Reference: Chemical Waste Management Report No. 87-117 (CWM 1987).

#00

#01 PB89-142426

#02 Field 68C*, 68D

#03 U052017

#23 Descriptors: *Industrial waste treatment, *Hazardous materials, *Regulations, *Standards, Phthalic acid.

#25 Identifiers: *Best technology, *Solid waste disposal, *Waste water treatment, *Volatile organic compounds(VOCs), Technology utilization.

#27 The document provides the background for EPA's rationale and technical support for selecting the constituents to be regulated in K024 waste and for developing treatment standards for those regulated constituents. The document also provides waste characterization and treatment information that serves as a basis for determining whether variances may be warranted. EPA may grant a treatment variance in cases where the Agency determines that the waste in question is more difficult to treat than the wastes upon which the BDAT treatment standards are based.

#30 0